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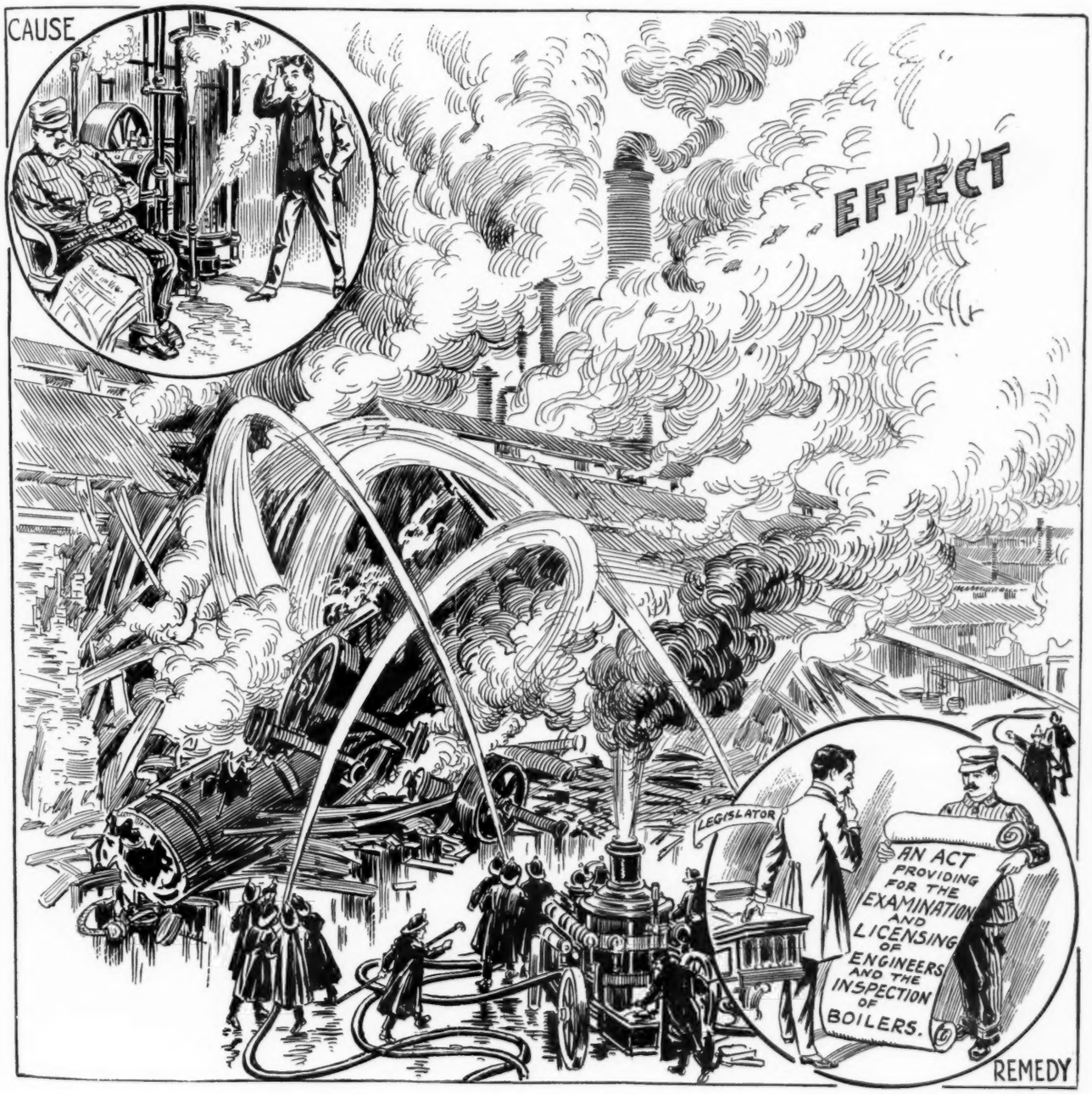

THE NEED OF LEGISLATION

(Suggested by George B. Longstreet, Somerville, Mass.)

New Sharp Mill Spray Cooling Pond

By Warren O. Rogers

SYNOPSIS—Owing to the distance and elevation from and above the harbor, a cooling pond with 120 spray nozzles has been constructed. The nozzles are set at such an angle that opposite jets impinge against each other, which further assists in breaking up the water.

Much interest has been manifested by the mill men of New Bedford, Mass., in the successful operation of the spray pond of the Sharp Manufacturing Co., of that city. It is only the second of its kind in that section; hence the interest shown.

Most of the cotton mills of New Bedford are located close to the water front and can easily obtain an abundance of condensing water, with short intakes leading to the suction pipes of the circulating pumps. The Sharp mill, however, has not this advantage, as it is about one-fourth mile from the nearest source of condensing water supply and is at an elevation of 35 ft. above the mean water level at low tide.

Fig. 1. Spray Nozzles and Cooling Pond

With the building of the mill came the problem of obtaining a sufficient supply of condensing water. The cost of laying a line of large water pipe from the harbor to the mill, added to that of constructing an intake and pumping outfit, together with the cost of operation, made such a proposition prohibitive. Then, after due investigation, it was decided to build a spray cooling pond using fresh instead of salt water in the condenser. Naturally there is some loss by evaporation and by mist being blown away by the wind, which loss is made up from the city water main. A view of the spray nozzles and cooling pond is shown in Fig. 1.

In the engine room, which is shown at the left of Fig. 1, is a 30 and 68 by 60-in. cross-compound Corliss engine, Fig. 2, which runs at 80 r.p.m. The English system of rope drive is used, and four sets of line shafting are driven from the grooved flywheel. There is also a 14x32-in. simple, four-valve engine directly connected to an alternating-current, three-phase, 60-cycle 600-volt generator, running at 164 r.p.m. The generator carries a motor and lighting load, a part of the factory machinery being motor-driven.

Condenser Outfit

Both engines are connected to a counterflow barometric condenser installed in the engine room, a general view of which is shown in Fig. 3. Circulating water is supplied by a 12-in. impeller pump directly connected to an 8x12-in. four-valve engine running at 150 r.p.m. The 10 and 27 by 24-in. dry-air pump runs at 50 r.p.m.

The condenser outfit produces a vacuum of 28 in. in regular daily service as indicated by the mercury column attached to the exhaust-steam leg. At the time of the writer's visit the overflow registered a temperature of 100 deg. F., with a 28-in. vacuum. The hotwell temperature is maintained within 4 or 5 deg. of the temperature of the exhaust steam. The counter-current feature of the condenser and automatic vacuum breaker enables the operator to run the condenser without danger of losing the vacuum should the temperature of the hotwell be the same as the exhaust steam.

Boiler Room

The boiler plant contains nine vertical boilers, each of 225 hp. capacity. The flue gases go to a 175-ft. brick chimney which is built on the outside of the boiler room. Boiler-feed water is handled by two 12 and 7½ by 12-in. outside-packed duplex pumps after passing through a multi-tube, exhaust-steam heater, which raises the temperature to about 200 deg. F.

In winter the mill is heated by hot air by a 11x20-ft. fan driven by a 16x24-in. slide-valve engine, at 70 r.p.m. In summer the air is cooled and washed by passing through sprays of water, which also produces the proper amount of humidity, necessary in textile manufacturing. Air is carried to the various rooms through metal conduits entering near the ceiling. The air-washing water is supplied by a turbine-driven centrifugal pump at 1700 r.p.m. and is forced through 2000 small spray nozzles. The supply of air is regulated by automatic dampers which permit the proper amount to pass through the washing water.

All engines are lubricated by a gravity oiling system the storage tank of which holds 500 gal. There are two 250-gal. oil filters.

A 4½x4½-in., triple-cylinder, motor-driven air compressor in the basement supplies air for controlling the humidifying system and blowing out the generator and motors.

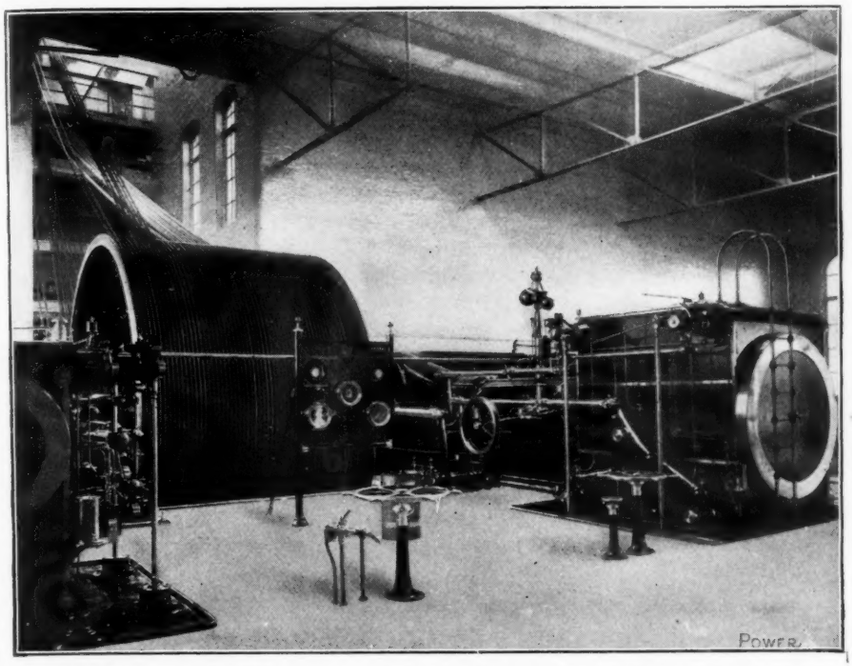

FIG. 2. CROSS-COMPOUND CORLISS ENGINE AND ROPE DRIVE

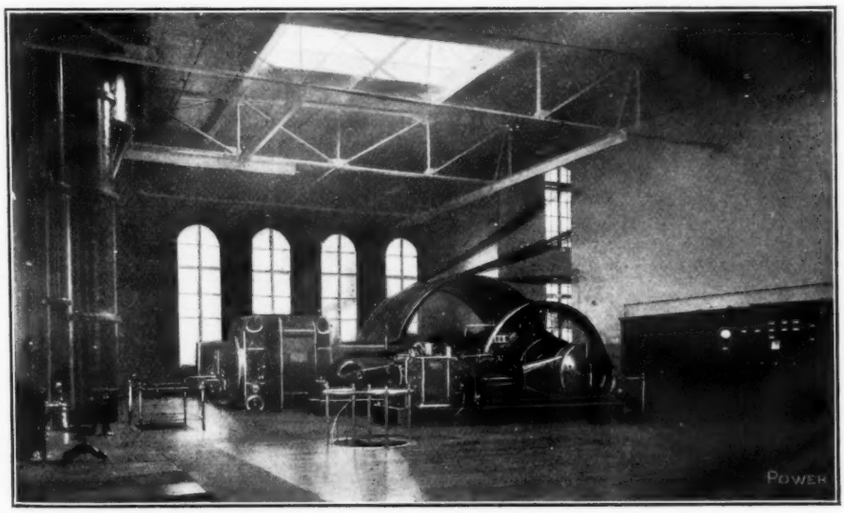

FIG. 3. GENERAL VIEW OF THE ENGINE ROOM

SPRAY POND

Circulating water is taken from the hotwell by a 12-in. centrifugal pump, directly coupled to a 30-hp. induction motor running at 1140 r.p.m., and forced through 120 two-inch spray nozzles. The pump house is at one corner of the cooling pond; the motor is controlled from the engine room.

The pond is designed to cool the water for a total of 3000 hp. of engines with a vacuum of 28 in. at the condenser. It is 4 ft. deep, 95 ft. wide and 140 ft. long and contains on the average, 400,000 gal. of cooling water. The condenser is supplied with water from a suction well at the end of the pond nearest the power house. A suction pipe from this well runs also to the fire pump, so that the contents of the cooling pond can be used for fire protection.

Three main spray lines branch out from a 14-in. header at the end of the pond nearest the power house. They are placed 25 ft. apart and extend lengthwise of the pond. At 12-ft. intervals the center spray heads are placed on the branch pipes, there being 24. Each head carries five 2-in. spray arms, each fitted with a 2-in. bronze spray nozzle, with a ¾-in. orifice. A gate valve is placed at the head of each branch pipe, and any branch of nozzles can be operated independently of the others.

A pressure of 5 lb. is maintained at the nozzles, which forces the water from the orifices in a fine spray. Each group of nozzles is set at an angle inclining toward the center nozzle, which is set vertical, so that the spray from one nozzle impinges

APPARATUS OF THE SHARP MANUFACTURING CO.'S POWER PLANT

No.	Equipment	Make	Purpose	Volts	Phase	Cycles	R.p.m.	Size	Pres. Lb.	Hp.	Manufacturers
1	Engine	Corliss	Main units	...	...	..	80	30x68x60″	..	..	C. & G. Cooper Co.
1	Engine	Rice & Sargent	Main units	...	...	..	164	14x32	..	..	Providence Engineering Co.
1	Engine	Porter-Allen	Circ. pump	...	...	..	150	8x12	..	..	Southwark Foundry & Machine Co.
1	Engine	Ridgway	Fan	...	...	..	70	16x24	..	..	Ridgway Dynamo & Engine Co.
1	Turbine	Steam	Air water pump	...	...	..	1700	.....	..	25	Kerr Turbine Co.
1	Generator	A.C.	Main unit	600	3	60	164	.....	..	..	General Electric Co.
1	Motor	Induction	Compressor	...	3	60	.....	.....	..	10	General Electric Co.
1	Motor	Induction	Pond pump	600	3	60	1140	.....	..	30	Crocker-Wheeler Co.
1	Compressor	Dayton	Air	...	...	..	.....	4½x4½	..	..	Platt Iron Works Co.
1	Pump	Centrifugal	Circ. water	...	...	..	150	12″	..	..	Southwark Foundry & Machine Co.
1	Pump	Porter-Allen	Dry air	...	...	..	50	10x27x24	..	..	Southwark Foundry & Machine Co.
1	Pump	Centrifugal	Air washing water	...	...	..	1700	.....	..	..	Buffalo Forge Co.
2	Pumps	Warren	Feed water	...	...	..	.....	12x7½x12″	..	..	Warren Steam Pump Co.
1	Pump	Centrifugal	Spray nozzles	...	...	..	1140	12″	..	..	Morris Machine Works
1	Fan	Buffalo	Heating	...	...	..	70	11x20′	..	..	Buffalo Forge Co.
9	Boilers	Manning	Steam gen.	...	...	..	.....	.....	150	225	Dillon Steam Boiler Works, D. M.
1	Chimney	Custodis	Smoke	...	...	..	.....	175′	..	..	Alphonse Custodis Chimney Construction Co.
1	Condenser	Barometric	Main units	...	...	..	.....	.....	..	..	Southwark Foundry & Machine Co.
1	Gage	Mercury	Vacuum	...	...	..	.....	.....	..	..	Holman and Maurer
1	Heater	Reilly	Feed water	...	...	..	.....	.....	..	..	Griscom-Spencer Co.
1	Humidifier system	Automatic	Air washing	...	...	..	.....	.....	..	..	Carrier Air Condition Co.
1	Oiling system	Fleur de Lis	Engines	...	...	..	.....	.....	..	..	Boston Steam Specialty Co.
1	Pond	Spray	Cooling water	...	...	..	.....	95x140x4′	..	..	Spray Nozzle Co.
120	Nozzles	Spray	Cooling water	...	...	..	.....	2″	..	..	Spray Nozzle Co.
9	Regulators	Williams	Feed water	...	...	..	.....	.....	..	..	Williams Gauge Co.

against that from the opposite nozzle, which assists in breaking up the water into still finer particles.

A feature worthy of note is the manner in which the spray-nozzle pump is piped, for water can be taken both from the condenser hotwell and also from the pond. This permits of spraying more water into the pond than is used by the condenser. This is desirable during the hot summer months, when the circulating water can be cooled to a lower temperature by pumping it through the nozzles more than once.

The water is taken from the hotwell at a temperature of 100 deg. F., and returned from the circulating pump at an average of 82 deg. F. in summer. The temperature of the pond water in winter is about 20 deg. F. above that of the atmosphere. In the fall and spring months the temperature of the air and water about balance.

The writer is indebted to Thomas R. Almy, master mechanic, under whose personal direction the plant was installed, for data pertaining to the various equipment.

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Horizontal Baffles in Water Tube Boilers

By Albert A. Cary

SYNOPSIS—Discussion of different ways of baffling water-tube boilers, the objections to each and the author's conclusions from his own experiments as to how and where baffles can best be used.

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In the Sept. 3 issue of Power, attention was called to the more or less troublesome horizontal baffles, commonly used in water-tube boilers. Mention was made of the bad effect on economy (and capacity might also be added) when holes occur through these baffles, due to their being either displaced or broken. The falling off in boiler performance, if they are removed, was also pointed out, and thus they remain, one of the necessary evils of the water-tube boiler. How and where baffles can be used to the best advantage in this type of boiler has been made a serious study by the writer.

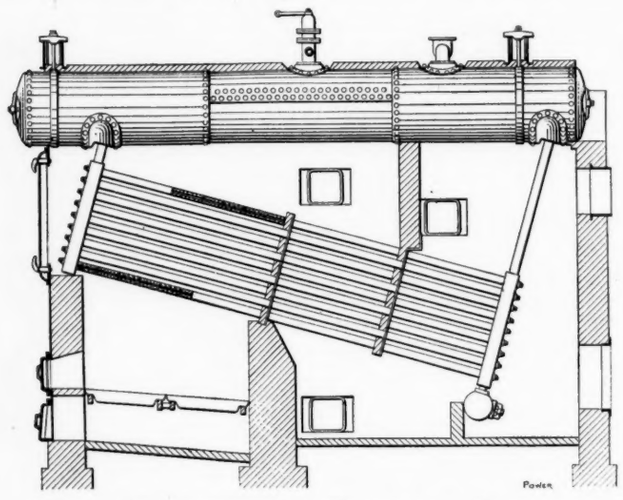

Fig. 1. Arrangement of Horizontal Baffles in Water-tube Boiler

When a solid baffle closes the openings between the tubes, the hot gases from the fire are deflected or else are caused to flow along beneath them. If solid baffles are arranged as in Fig. 1, these gases run toward the rear of the boiler, under the lower row of tubes (and baffles) until they reach the opening near the vertical flame plate. They then flow upward through the bank of tubes, taking the shortest path, and escape through the opening at the top of the first pass between the end of the upper baffling (placed upon the top row of tubes) and the front header. By taking this direct path of least resistance, these hot moving gases have no chance to flow over those parts of the tubes immediately above the lower baffle and below the upper baffle and thus two stagnant pools of gas having little or no motion are found in these troublesome corners. As there are no fresh, active streams of hot furnace gases flowing through these pockets, the gas found there has very little additional supply of heat to replace the heat which has been abstracted by the tubes it bathes and consequently its temperature drops, thus making this part of the heating surface correspondingly less effective.

In three tests made by the writer to determine the temperatures existing throughout boilers of this type, which were equipped with but fairly tight horizontal baffles placed similar to the arrangement shown in Fig. 1, he found the following results:

	Degrees Fahrenheit		
	No. 1	No. 2	No. 3
Temperature of gases entering end of lower baffle....	2640	2580	2020
Temperature above lower baffle.....	980	960	745
Temperature of flowing gases leaving top of tubes...	680	660	605
Temperature beneath top baffle.....	510	490	430

In testing a water-tube boiler with horizontal baffling placed along the lower row of tubes and carrying the gases to the rear end of the boiler, he found

Temperature of gases entering the openings between the lower row of tubes.....	2010 deg.
Temperature above front end of baffle.....	420 deg.

The loss in heat transmitted is, unfortunately, not limited by the loss in temperature found in these dead spaces. A vessel containing water can have the temperature of its contents raised to the boiling point very much quicker when it is heated by the rushing flame from a blast lamp than when it has a quiet flame of equal temperature applied to its bottom. The rapidly moving gas flame passing over the heating surface with considerable velocity tends to decrease the film resistance which opposes the rapid transmission of heat. Thus a more rapid transmission of heat can be expected where the hot furnaces gases are constantly moving over the heating surfaces than when they are surrounded with an almost motionless envelope of gas.

The draft area, between the tubes in the type of water-tube boiler, shown in Fig. 1, is disproportionately large, especially for a fuel containing volatile matter. Usually this free draftway is almost 43 per cent. of the grate area. By comparing this draft area with that ordinarily found in horizontal tubular boilers (through the tubes) the difference is quite striking.

When the volatile gases are distilled from a fresh charge of bituminous coal, with the grate under the first

pass of a water-tube boiler not equipped with baffles, these gases, finding such a free path of escape among the tubes, rush upward, out of the hot furnace, and are in the center of the bank of tubes above before they have time to complete their combustion. As the temperature of these tubes is seldom above 365 deg. F. and as combustion ceases when these gases are chilled below 1400 deg. F., much of their available heat is lost, due to suppressed combustion, and smoky chimneys are likely under these conditions.

Partly closing the openings between the tubes, so as to decrease the draft area, opposes greater resistance to

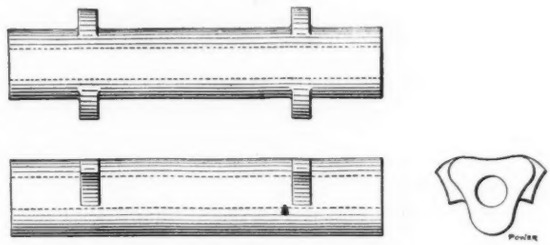

FIG. 2. AUTHOR'S SPECIAL FORM OF BAFFLE BRICK

the free escape of the unburned gases generated in the furnace and better results may be looked for.

Theoretically, all the furnaces gases should be completely consumed in the furnace and its combustion chamber before they enter the boiler where the surrounding chilly surfaces will lower their temperature below their critical temperature of combustion. Thus the need of some form of baffle to secure conditions which approach this theoretical requirement, becomes apparent.

Evidently, then, horizontal baffling in the passageways of the furnace gases in water-tube boilers has two purposes: to guide a constantly flowing stream of hot gases over the greatest possible area of the boiler's heating surface, and to promote the best conditions in the furnace, so as to secure the most complete combustion of the gases before they enter the chilling, heat-absorbing surfaces of the boiler.

The writer has experimented with various arrangements and forms of horizontal bafflings in water-tube boilers, using both the pyrometer and gas analysis to determine the results obtained and found the problem more complicated than he originally anticipated.

One of the first ways, and apparently the simplest, to overcome the objections cited above, was to place the solid baffles on the tubes so that a space would be left between their ends, which allowed the furnace gases to pass between them. This, at the start, showed a small improvement over the old, solid (end-to-end) arrangement and tests were made with even spacing between the baffles and also another arrangement was tried in which different distances between the various rows of baffles (running from side to side of the boiler) was tried. This latter arrangement proved the most satisfactory, but in continuous use the smaller openings soon became clogged with dirt. Further, these baffles became displaced from using the steam-cleaning pipe and due to other causes, so that many of the slit-like openings were closed, leaving undesirably large openings between the ends of other adjoining baffles. When the fire was forced, the burning gases rushed through these slits, like the flame of a blow pipe and impinged at separated spots upon the tube immediately above and, further, the ends of some of these baffles on the lower row showed evidences of fusing.

Another form of baffles used had vertical holes cast through their center, which were located over the space between the tubes. With this form of baffle, the blowpipe action, described above, when the fire was forced, was even more apparent. Some of the holes became clogged with dirt and breakage through the holes occurred.

Failing to find any other form of baffle to overcome these troubles, the writer invented a modified form of baffle to overcome the objections he had found, and has been allowed a United States patent for it. As it becomes interesting in the discussion of this subject, he offers the following description:

As the solid form of baffle proved so undesirable this principle of complete closure of the openings was discarded, and a throttling medium was chosen instead, which had the form of a specially shaped refractory brick, shown in Fig. 2.

At *A*, Fig. 3, it will be seen that this brick is easily introduced into the bank of tubes, by passing it between any two adjacent tubes. It can then be turned, as at *B*, and finally dropped into its normal position, as shown at *C*.

Owing to the tendency of this lower row of tubes to bend and sag it is generally desirable to insert such a form of baffle in the spaces of a row of tubes above. This is easy when using a stick or pole having a pin projecting

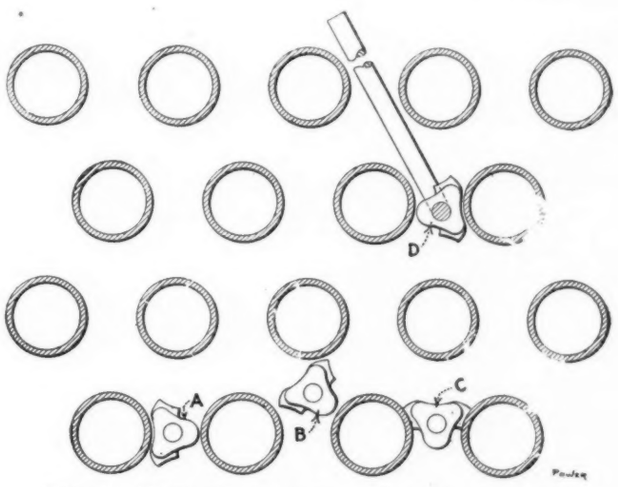

FIG. 3. HOW THE BAFFLES ARE PUT IN PLACE

at right angles to its axis and fastened to its outer end (the opposite end of the pole being held in the hand). With this projecting pin placed in the central hole (which runs lengthwise through the brick) the brick is passed downward (or upward) through the nest of tubes until the required position is reached, when the brick is turned and dropped between the tubes where required. This is illustrated at *D*, Fig. 3.

The brick is held in position between the tubes by four projecting lugs, which hold the body of the brick (in some cases ½ in.) away from the tube. Thus, in certain cases, instead of finding a 3-in. wide opening between the unbaffled tubes, with these throttling bricks in place, there will be an opening of only ½ in. on each side of the brick.

With the free draftway between the tubes thus throttled, enough hot furnace gases are passed along under the

lower row of tubes to completely bathe the rear end of the tubes in the first pass, while, at the same time, sufficient gas will pass through these throttled spaces, between the tube and the brick, to keep a mass of gas flowing constantly over the tubes above the throttled area.

A similar effect is produced under the top row of baffles (as shown in Fig. 1) where the diminished openings will allow a flow of hot gases between the sides of these bricks and the tubes sufficient to break up the pocket of stagnant, motionless gas. At the same time, these upper throttling bricks drive enough of the gases forward to the front end of these tubes to surround them with an active flowing stream.

The top row of baffling brick can sometimes be placed to better advantage on the second row of tubes from the top, so that during the time of cleaning, men can walk over the top tubes without danger of displacing the bricks below their feet.

The passing of hot burning gases through the diminished opening cannot cause a blow-pipe effect upon the tubes above, when the furnace is forced, and as this thin stream of gas has water on one side to rapidly absorb its heat, the effect upon the solid side of the adjoining brick surface is not destructive.

The hole running lengthwise through the brick has another object. When a solid brick is quickly heated, its exterior is soon raised to a high temperature, while time is required for the heat to penetrate to the center and the reverse is true in sudden cooling (as when a furnace door is opened). This causes unequal expansion and contraction throughout the mass and solid baffle bricks are frequently broken, due to this cause. The hole through the center of this throttling brick reduces this trouble.

Expansion and contraction of the tubes themselves as well as their spreading or drawing together are cared for by the brick's form and location. The side lugs rest upon the upper part of the circumference of the tubes so that any diminishing of the distance between the centers of these tubes causes the whole brick to rise, thus avoiding a crushing effect.

A straight-edge laid across the top of the tubes will show that the whole body of the brick is below this level, and thus the steam-jet pipe can be used for blowing off the accumulated dust without interfering with the bricks.

The furnace element of this problem is also met with this throttling brick, as most of the gas distilled from the fuel is throttled back in the hot furnace, beneath the baffles and to secure the same effect as is obtained by solid baffling, a longer line of these throttling bricks must be used, due to the designed seepage which takes place along their entire length. Thus, the effect of a fire arch over the grates is more nearly approached, which becomes of greater value as the combustible volatile matter in the fuel increases.

These throttling bricks properly distributed in the last pass of the boiler (as in Fig. 1) will cut down the draft area there, causing a better distribution of the hot gases over the entire heating surface, followed by the lowering of the temperature of the escaping gases, thereby promoting economy.

The rational baffling of the hot gases passing through water-tube boilers, unfortunately, has received too little careful study. Consequently, many of the baffles used are designed with little other thought than providing some means for obstructing the flow of these gases, and the consequences following their misuse are seldom considered with a view of their effect upon the efficiency and capacity of both the boiler and furnace.

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Deductions from Tests on Pipe Fittings

SYNOPSIS—A 4-in. swivel joint on a steam pipeline was tested as originally designed and as reconstructed with heavier flanges and more bolts to meet the requirements of the insurance inspectors. The latter arrangement, however, proved only 68 per cent. as strong as the former, due largely to the increased diameter of the bolt circle and the consequent greater leverage.

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Interesting results have come to light in connection with some tests of pipe fittings, which were conducted by a corporation on fittings made in its own foundry for its own use. The tests were made under hydraulic pressure.

The principal test was that of a 4-in. swivel joint used on the vertical leg of a steam pipe from a boiler, to allow the easy movement of the main steam pipe under its natural contraction and expansion. Fig. 1 shows this joint in elevation and section as arranged for testing. It is now giving satisfactory service under a working pressure of 150 to 160 lb. This joint, as built to meet the demands of the insurance inspectors, for service at the same pressure is shown in Fig. 2. The flanges are 1¼ in. instead of ¾ in.; the base is 1 in. instead of ⅝ in. and the gland with its ring has eight bolts in place of four.

Several interesting features developed during the tests of these two joints. At 700 to 800 lb. pressure, all flat packing blew out and $\frac{5}{16}$-in. packing, set in grooves as shown, became necessary. At 1100 lb., the flange on the brass sleeve began to dish (as shown dotted, Fig. 1). Ring *B* remedied this trouble. The 1⅛-in. heads also gave way at this pressure, and 2-in. heads were supplied. At 1500 lb., the new and supposedly stronger joint gave way, cracking the cast-iron ring directly over the split in the gland, as shown in Fig. 3. The bolts adjacent to the split were overstressed and lengthened while the other four bolts were entirely loose. The older form gave way at 2200 lb., when the base cracked, as is shown for two tests in Fig. 4.

This, apparently, does not admit of exact calculation. It may not be amiss, however, to inquire somewhat into the failure, and draw some conclusions therefrom.

In the first place, let it be noted that both the base and gland bolts were smaller than constitute standard practice for this working pressure. The stress in bolts of these sizes (⅝ in. and $\frac{11}{16}$ in.), caused by the force necessary to make the joint tight, reduces the factor of safety very materially; in fact, experiments along this line lead to the belief that it is considerably below two, the additional stress resulting from the pressure not being considered at all.

Figs. 3 and 5 show in plan the split gland and bolts of both the old and the rebuilt joints. The pressure on the

shaded areas, in each case, is supported by the two bolts adjacent to the split. In the rebuilt joint, each of these bolts is assumed to carry one-sixth the total pressure load, the break showing that these bolts were stressed beyond the others. The line *AB* represents, in each case, the center line of the pressure and *CD* the center line of the

These tests and the results therefrom merit consideration from several points of view. In the first place, under 150 to 160 lb. working pressure, the system has a factor of safety of 5. It is no stronger than its weakest part, the packing, which could not be made to withstand over 700 to 800 lb. Manufacturers of fittings recognize

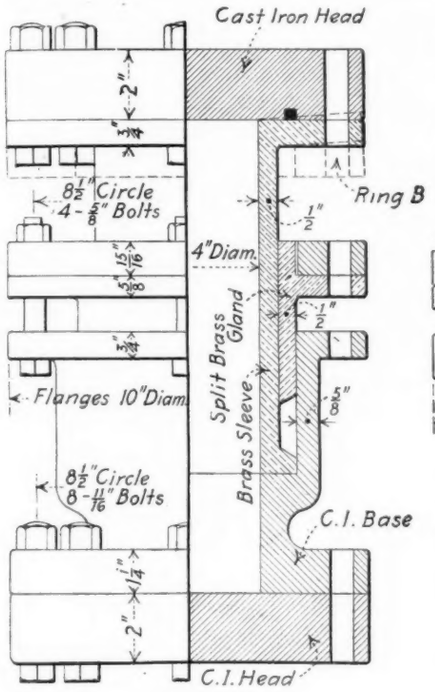

Fig. 1. Original 4-in. Swivel Joint

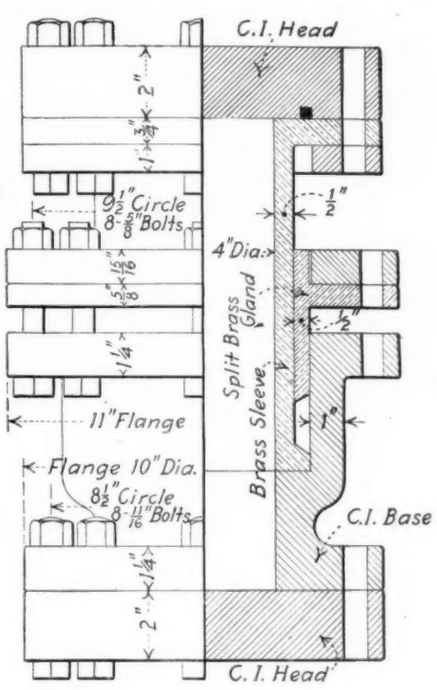

Fig. 2. Joint as Rebuilt

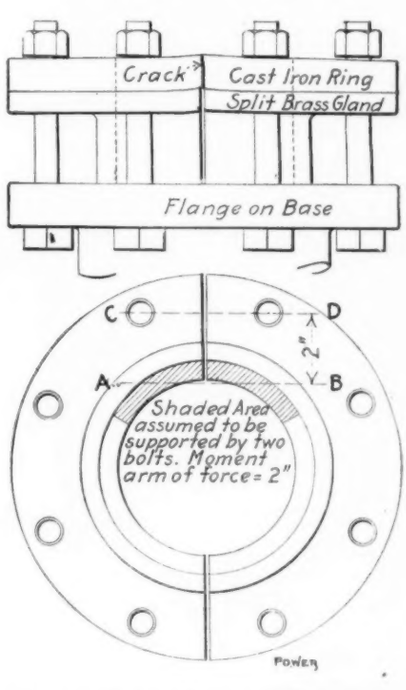

Fig. 3. Gland Bolts on Rebuilt Joint, and Failure Indicated

resisting bolt pull. The eccentricity of the load, nearly double in the rebuilt joint, would seem to account for the failure, the bolts nearest the split lengthening and allowing the ring to give way.

Other tests by the same corporation, on its own high-

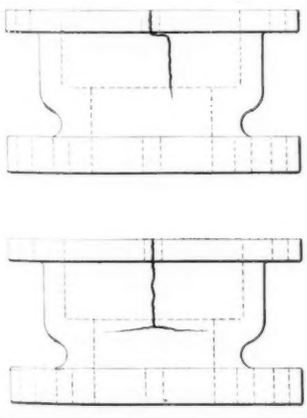

Fig. 4. Bases of Old Joint Showing Failure

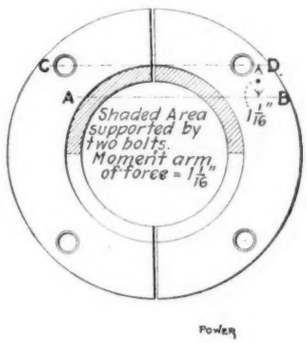

Fig. 5. Gland Bolts on Original Joint

pressure fittings, gave the following results: A cast-iron flanged tee gave way at 1800 lb., and a flanged elbow at 2300 lb., the failure in both cases being due to the flanges. Four-inch standard weight wrought-iron pipe gave way at 1600 lb. A threaded brass elbow began to leak at 2200 lb., and at 3300 lb. became so badly distorted that the pressure could not be held.

this in specifying grooved and lipped flanges on all extra-heavy work. The next weakest parts, the flanges on the sleeves and heads, have the very reasonable factor of safety of 7.

Moreover, the joint was rebuilt upon the refusal of the insurance companies to accept the risk as installed and, in the new form, met all their requirements. Yet, upon test, it developed only 68 per cent. of the strength of the original joint.

The most careful study is necessary to predict the behavior of a new design. In this case, notwithstanding the fact that the base and its top-flange were thickened, and the number of gland bolts doubled, this added strength was lost in the increase of the bolt circle.

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What is said to be the largest cable in the world was tested recently in the 800,000-lb. testing machine of the Fritz Engineering Laboratory, Lehigh University, South Bethlehem, Penn., when it withstood a pull of 364 tons before breaking. The cable consists of six strands, each of 19 wires, twisted around an independent wire-rope center, this center having six strands of 19 wires each, twisted around a hemp core. The finished cable was 7810 ft. long and weighed 125,360 lb. It is used by the Spanish-American Iron Co. in Cuba to lower wagons with a capacity of 100,000 lb. of ore down an inclined plane 5800 ft. long.—"Mechanical World."

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The complexity of business done by the great German electrical manufacturing concern, the Allgemeine Elektricitäts Gesellschaft, is shown in a summary of the annual report printed in the "A. E. G. Journal" for December, 1912. Out of the business profits, a dividend of 14 per cent. will be distributed after setting aside 3,000,000 marks as a contribution to the reserve fund which now is increased to half the amount of the share capital.

Development in Marine Condensers

SYNOPSIS—Mr. Weir replies to Mr. Morison's criticism of his paper and depreciates his theory concerning films of air forming around the tubes. He is a firm believer in air pumps and thinks that an excessive vacuum for a marine turbine costs more than the gain.

In POWER of Jan. 21, an article on the above subject by William Weir before the Institution of Engineers and Shipbuilders in Scotland, was published, and following was a discussion of the paper by D. B. Morison, in which he presented a new theory of condensation. Mr. Weir's reply to this discussion may be of general interest.

In the first place, Mr. Weir objects to the importance and value placed on Prof. Weighton's paper of 1906. The paper in question dealt with the comparative performances of two condensers, one an old-fashoned rectangular condenser of small size, unrepresentative of practice at that date, and the second a condenser with certain special features of design. The trials show that the new condenser gave a better performance than the old one. Professor Weighton and Mr. Morison attributed the improvements to compartmental drainage of the feed water, so that the surfaces in the lower compartments are not impeded in their condensing action, abolition of the steam space and the substitution of a passage of such shape and section as to secure the distribution of the steam over the whole length of the tubes, and tubeless passages connecting the compartments.

The correct value of Professor Weighton's paper can be measured by the extent to which the alleged improvements have been embodied in modern designs. In the last four years Mr. Weir has personally been associated with the design of condensers for about nine million horsepower, embracing the most important examples in marine practice, and in not a single case are the condensers divided into compartments, nor are they sectionally drained; they have all more or less a steam space, and none of them have tubeless passages. Even in his own recent practice, Mr. Morison does not appear to embody these particular features to any extent. In the 1906 design of the Contraflo condenser, section drainage was provided for, but in succeeding designs this features has been gradually eliminated. The factor which was really responsible for the better performance of the 1906 condenser was undoubtedly the increase in velocity of flow of the circulating water through the tubes.

With reference to Mr. Morison's remarks regarding the provisions for dealing with large quantities of air leakage, resulting from accidental leakage into the system, Mr. Weir had had no experience of accidental leakage which a normal air pump could not handle satisfactorily until the accident had been repaired, and in his opinion there is no need of providing air pumps to maintain the highest degree of vacuum under other accidental conditions.

In the attainment of high vacua, Mr. Morison gave considerable space on how to best treat the small quantity of air which normally enters the condenser with the steam, and incidentally cited some experiments carried out by J. A. Smith to determine the effect of air on the heat transmission through a condenser tube. It was Mr. Weir's opinion that any theory or practice based on these experiments would be absolutely valueless, as the results could have no bearing whatever on surface condenser design or practice. Mr. Morison confirms the unfortunate effect of these results when he states that a film of air of minute thickness has a degrading effect on the heat transmission of a condenser tube. In the first place, there are no films of air, nor are there any films of steam in a condenser. There is a mixture of air and steam or air and aqueous vapor, each occupying the whole space. One of Mr. Weir's essentials of design is that the steam path must be such as to maintain a velocity of steam flow, and this is a most important factor. The relative weights of steam and air play no appreciable part in these condenser phenomena. In Mr. Smith's experiments the steam conditions were practically static, and the flaw in Mr. Morison's theory and conclusion is that he always considers a condenser in a static condition rather than in a working condition. The effect of air in a working surface condenser, is not in any way due to a resistance imposed on heat transmission by its presence and through being a poor heat conductor, but solely and simply to the physical conditions of temperature and pressure caused by its admixture with aqueous vapor.

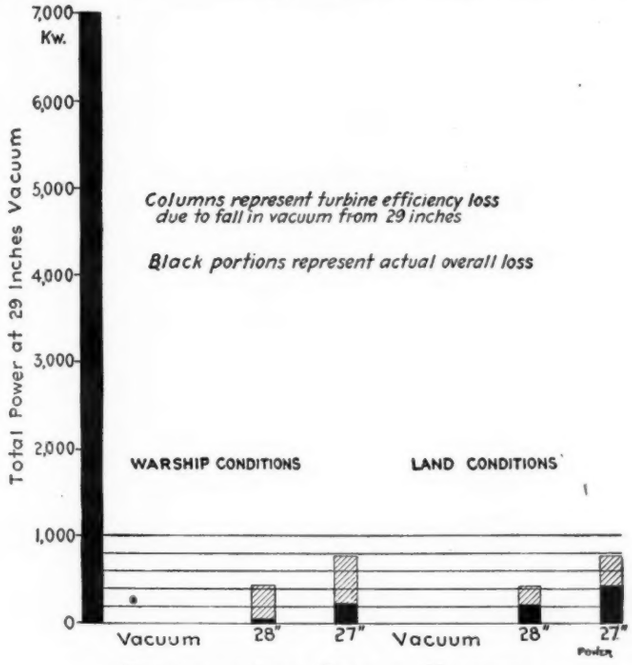
In a working condenser, the phenomenon consists of a mass of cooling surface working at high transmission rates with a more or less clearly defined air zone wherein the total transmission per square foot (not per degree difference per square foot) is impaired, due to the physical conditions of temperature and pressure. Accordingly, if the essential condition of uniform steam flow be maintained in a condenser design, the contour of the condenser becomes a wedge, and having obtained that, all else is dependent on the air pump, assuming fixed circulating-water conditions. The function of the air pump is to reduce the air-zone level, and to allow the working part of the condenser to extend itself, and only the air pump can perform this function.

Mr. Morison's remarks regarding eddies and means of preventing air particles making multiple appearances in any one plane can hardly be accepted as serious when the actual velocities are remembered. The idea of an air particle "lingering" in a modern condenser with uniform steam flow requires a great effort of imagination. The worst eddies in a condenser are those caused by the tubes. Any other eddy troubles are caused by the presence of baffle-plates or deflectors, such as were advocated by Mr. Morison.

In reply to the criticism of Mr. Morison concerning his statement that in reciprocating marine installations the highest attainable vacuum is not synonymous with overall economy, Mr. Weir refers to the diagram published by Sir Charles Parsons in the early days of the turbine, showing the effect of vacua on the steam consumption. This diagram was practically reproduced by Mr. Morison, and is probably literally correct, but is used and applied, and inferences drawn from it, in a dangerous and misleading manner. The diagram shows the effect of a drop of 2 in. in vacuum from 29 in. on the steam consumption of the main turbine. Mr. Morison applies this commercially, but take a power

station for example; money is not expended on the direct purchase of steam; it is coal which is purchased. The diagram does not show the effect of the vacuum drop on the only item which matters—the coal. The correction for the higher hotwell temperature and the reduced cost for circulating water for the 2 in. in question is a very important matter, but is completely ignored by Mr. Morison. As the effect of these factors varies according to the type of installation a diagram has been prepared and presented herewith, showing the necessary corrections for two conditions, the first being a power-station condition with 55 deg. inlet water and electrically driven circulating pumps; the second condition being a British warship with steam-driven circulating pumps, wherein the exhaust is led to the low-pressure turbine, and not to the feed water. As may be inferred from this diagram, Mr. Morison's figures, in the sense in which he asks them to be applied, are wrong to the extent of 35 per cent. in one case and 65 per cent. in the other.

Mr. Weir stated that his firm had recently supplied designs for a condensing plant to a foreign navy for a



EFFECT OF 2-IN. DROP IN VACUUM

very high-speed cruiser, wherein the vacuum at full power is 27¼ in., and he is prepared to demonstrate that this will be the best vacuum for that ship at full power. In his opinion the value of a vacuum over 28½ in. for marine turbines is open to question. Almost everything in engineering is a compromise, and while on the one hand a fair percentage of improvement in the steam consumption might be obtained, on the other hand, the increased circulating-pump consumption, the increased weight and space for air and circulating pumps, the increased weight and space of the main condensers, the effect of reduced hotwell temperature, the increased weight and space of the low-pressure turbine to satisfactorily utilize the high vacuum must be considered, and, in the end, we may come, perhaps, to regard even for turbines a practical limit in the reduction of back pressure as desirable.

New Refractory Cement

The H. W. Johns-Manville Co., New York City, has recently put on the market the "J.-M High Temperature Cement No. 31" which, it is said, can be used wherever temperatures range between 1500 deg. and 3100 deg. F.

This material is a dry powder mixture composed of asbestos and other materials. It is mixed with water to the proper consistency by adding 18 to 20 lb. of water to 100 lb. of powder.

When used for setting firebrick for boilers and furnaces, lining and roofing furnaces of various kinds, lining fire-doors, repairing side walls of furnaces, making stay-nut caps, etc., it is said to have considerable mechanical strength, and that, when air dried, it will withstand a crushing strain of 883.5 lb. per sq.in. It vitrifies at the comparatively low temperature of 1418 deg. F. and has a high melting point, 3182 deg. F.

Being semi-acid in character, it can be used with chrome bricks, silica bricks or fireclay bricks. It is claimed that experiments with this cement show that it can be successfully used in building doors of angle-iron framework without backing, or for making one-piece linings for gas- or oil-burning crucible furnaces.

Connellsville Electrical Plant

The Western Maryland Railway Co. has been making a thorough study of the Western Penn Traction & Water Power Co.'s plant at Connellsville, Penn., and the proposed hydro-electric operations, having in view the possible use of power from this plant in connection with the proposed industries at Connellsville and other points.

Of the company's development operations, Austin Gallagher, its industrial commissioner, says: "This company has at the present time a steam plant at Connellsville with 52,000 hp. capacity, running on coal costing about a dollar a ton, which it is expected will favorably compare with almost any hydro-electric plant. In addition to the power now possessed, the West Penn Co. is preparing to put in three dams on the Cheat River, Va., which will produce 50,000 hp. each—the first to be in operation Jan. 1, 1914—and dams will be built on Sandy Creek, in West Virginia, providing more power.

"The company also controls the falls at Ohiopyle, Penn., where there is a drop of 110 ft. in a very short distance, together with the reservoir rights on the Youghiogheny River, so that ultimately there will be an electric power equal to 250,000 or 300,000 hp. that can be used for commercial purposes. The existing power is being carried 120 miles to Butler, Penn., under a voltage of 22,000; 3000 hp. is being conducted 28 miles to a large coal-mining company. At the present time, 110 coal mines, consuming 200 to 5000 hp. each, are being supplied from this plant. Municipal water-works also are being operated quite freely by electricity produced by this company. With the establishment of the hydro-electric plants, a voltage of 110,000 will be adopted for long distance."

The West Penn Co. claims to be selling power as low as any other plant east of the Mississippi and north of the Mason and Dixon line, and this development must of necessity become the center of a wonderful industrial growth, as these plants are located in the midst of millions of tons of coal that can be cheaply mined.

Factor of Evaporation

By A. A. Potter

SYNOPSIS—The tentative report of the subcommittee of the Committee on Tests of the American Society of Mechanical Engineers recommends the calculation of the factor of evaporation as for dry-saturated steam, and the use of a correction factor for departures from this quality.

The author considers it more simple and logical to compute the heat contents, whatever the quality, before dividing by 970.4 and shows simply how this is to be done for moist or superheated steam.

The factor of evaporation is that number by which the water evaporated in a boiler must be multiplied in order to obtain the equivalent evaporation from and at 212 deg. Thus it is the ratio of the "heat contents" of one pound of steam at a given pressure, reckoned from the feed-water temperature, to the latent heat of evaporation of steam at 212 deg.

The "heat contents" of one pound of steam at a given pressure is equal to the heat of the liquid (the h of the steam tables) plus the latent heat of evaporation at that pressure (the L of the steam tables) if the steam is dry. If the steam is wet, the latent heat of evaporation must be multiplied by the quality of the steam and this product added to the heat of the liquid in order to obtain the heat contents. When the steam is superheated, the product of specific heat of superheated steam by the number of degrees of superheat is added to the heat contents of dry steam at the given pressure. The total heat contents of a pound of superheated steam may be found in some of the steam tables for different pressures and degrees of superheat.

In the boiler code of 1912 submitted in the preliminary report of the power-test committee of the American Society of Mechanical Engineers and published in the November issue of the society's *Journal*, the method for calculating equivalent evaporation is given as follows:

"The equivalent evaporation from and at 212 deg. F. is obtained by multiplying the weight of water evaporated, corrected for the moisture in the steam, by the factor of evaporation. The latter equals

$$\frac{H - h}{970.4}$$

in which H and h are respectively the total heat of saturated steam and of feed water entering the boiler."

The method for correcting for moisture in the steam is given as follows:

"When the percentage is less than 2 per cent., it is sufficient merely to deduct the percentage from the weight of the water fed. If the percentage is greater than 2 per cent. or if extreme accuracy is required the factor of correction equals

$$Q + P\frac{(T - h)}{(H - h)}$$

in which Q is the quality of steam (one minus the decimal representing the percentage of moisture), P the proportion of moisture, T the total heat of the water at the temperature of the steam, h the total heat of the feed water, and H the total heat of saturated steam of the given temperature."

To calculate the equivalent evaporation by deducting the percentage of moisture from the feed water and multiplying the remainder by the factor of evaporation for dry steam is inaccurate and should be used only in approximate calculations.

In the process of steam generation, heat must be added to the feed water to bring its temperature up to the vaporization temperature at a given pressure, and when this temperature is reached the additional heat required for the vaporization process, or the latent heat of evaporation, depends on the final quality of the steam. Thus if the steam is 3 per cent. wet, the heat required to vaporize one pound of water at a pressure of 150 lb. abs. is 0.97 times 863.2, or 837.1.

In the above computation 0.97 represents the quality of the steam, or one minus the decimal representing the percentage of moisture; 863.2 is the latent heat of evaporation into dry steam at 150 lb. abs., or the heat required to vaporize completely one pound of water into steam at the given pressure. The value used here is that given in the Marks and Davis steam tables.

To obtain the heat contents of one pound of steam at 150 lb. abs. and quality 0.97 dry, the heat of the liquid, or the heat required to bring up one pound of water from 32 deg. to the vaporization temperature at 150 lb. abs., must be added to 837.1. This makes the heat contents:

$$837.1 + 330.2 = 1167.3\ B.t.u.$$

In order to apply this to the calculation of the factor of evaporation, the feed-water temperature must also be known. If this temperature is taken as 130 deg., the heat of the liquid corresponding to this temperature, reckoned from 32 deg., is 97.89. Since the heat of evaporation at 212 deg. is 970.4, the factor of evaporation is:

$$\frac{1167.3 - 97.89}{970.4} = 1.11$$

For a boiler showing an evaporation of 5000 lb. of water per hour, the equivalent evaporation from and at 212 becomes:

$$1.11 \times 5000 = 5550\ lb.$$

With dry steam, and other conditions the same as given in the above example, the factor of evaporation is:

$$\frac{863.2 + 330.2 - 97.89}{970.4} = 1.13$$

The equivalent evaporation from and at 212 deg. would be:

$$1.13 \times 5000 = 5650\ lb.$$

If the temperature of the steam in the above example was 450 deg., or superheated:

$$450 - 358.5 = 91.5\ deg.$$

the factor of evaporation becomes in this case:

$$\frac{863.2 + 330.2 + 0.57 \times 91.5 - 97.89}{970.4} = 1.18$$

in which 0.57 represents the specific heat of superheated steam or the heat in British thermal units required to superheat the steam one degree at the given pressure and temperature.

The equivalent evaporation in this case is:

$$1.18 \times 5000 = 5900\ lb.$$

ELECTRICAL DEPARTMENT

Motors and Motor Applications—III

By A. B. Morrison, Jr.

Direct-current Motors

The construction of direct-current motors is so well understood that a description is unnecessary; consequently, only their operating characteristics will be considered. Direct-current constant-speed motors are of the shunt- or compound-wound type. For most installations, where the voltage is approximately constant, the shunt-wound motor gives more nearly constant speed. On circuits with widely varying voltage, the compound-wound motor gives better speed regulation than the shunt wound, and more satisfactory operation.

The ordinary commercial shunt motor will develop approximately 225 per cent. of full load torque with from 185 to 200 per cent. of full load current. Where the starting duty is heavy a compound winding is used by which the starting torque can be increased to 250 per cent. or more, depending on the amount of compounding with a starting current of 200 per cent. of full load current or above. Where constant speed is desirable under a varying load the compound winding can be cut out after the motor is up to speed.

There is one peculiarity of a shunt-wound motor as commonly used which is not always recognized. When the motor is operating "cold" (before the load has been on long enough for the motor to warm up) the speed is from 4 to 5 per cent. lower than after the motor is warm. This is due to the lower resistance of the fields when cold. In the case of centrifugal pumps particularly, where a given constant speed may be essential, the failure of the motor to run at rated speed when cold may cause the pump to fail to pick up, whereas, if the pump picks up with the motor cold the increased speed when the motor is hot may overload it. This peculiarity should be recognized and suitable provision made for it either in the pump itself or in a device by which the speed of the motor can be changed slightly.

Between no load and full load the ordinary shunt motor without interpoles will drop from 4 to 5 per cent. in speed. With interpoles the drop can be practically eliminated or the speed even increased slightly under load. With a variation in line voltage the speed of the motor varies proportionately to the voltage, but not directly so. For instance, with a motor running on 230 volts, a drop in voltage to 220 volts will not cause the speed to be $\frac{220}{230}$ or 95.5 per cent. of what it was at 230 volts, but the drop in speed will be about 70 per cent. of the voltage drop, or, in this case, the drop in speed will be $(110 - 95.5) \times 0.70 = 3$ per cent., approximately.

Series Motors

Series motors are nearly all used with hand control, where the operator can watch the work, as the speed varies widely under load depending upon the torque demanded and if the load is thrown off the motor will run away. The application of a series-wound motor is usually very special. In general, the placing of a series winding on a shunt motor makes the speed vary widely under load, so that if heavy starting torque is essential, and inherent speed regulation is desired after the motor is operating, the series winding must be cut out after the motor is up to speed.

For variable-speed work the direct-current motor is preeminent. Speed control can be obtained by the insertion of resistance in series with the motor, this armature resistance producing a reduction in speed with constant torque. The objections to this method of control as regards unstable speed as the load varies, the size of control equipment and poor economy are the same as mentioned under the variable-speed, alternating-current wound-rotor motor with resistance in the secondary circuit. By varying the field resistance, however, a constant horsepower, variable torque motor is produced with speed variations as high as six to one. At any given speed the drop from no load to full load is very slight.

The characteristics of an adjustable speed motor, aside from the speed features, are similar to the nonadjustable type. The horsepower rating of the motor is usually the same at all speeds. This, however, may not be strictly true as at the lowest speed the rating may have to be decreased due to the poorer ventilation and consequently greater heating. In applying an adjustable speed motor it should be remembered that the size and consequently the cost are directly dependent on the horsepower developed at the lowest speed. For instance, suppose the application requires a 5-hp. motor with a speed range of from 200 to 1200 r.p.m. This motor must, of course, be large enough to develop its rated horsepower at the lowest speed of 200 r.p.m. If, however, the speed range could be decreased from 300 to 1200 the motor would only have to develop its rating at 300 r.p.m. or would need to be approximately only $\frac{2}{3}$ as large. In many applications the motor runs at the lowest speeds only very intermittently and the horsepower required is less than that at higher speeds. In such cases a very considerable saving in first cost and size of motor can often be made by using field control down to a certain point and armature control for the lowest speeds.

There are several other methods of obtaining adjustable speed in motors, but the field-control method is the most widely used and probably the best for most installations. Multiple-voltage systems where different voltages can be applied to the motor can be utilized in some cases, but usually only one voltage is available.

Comparing the direct-current motor with the multiphase-induction type, the former, for constant-speed work, possesses the great disadvantage of a commutator with constant attention necessary. Therefore, wherever possible to use it, the multiphase-induction motor is preferable on account of simplicity and less liability to give trouble. Where adjustable speed is required, however, the direct-current motor is by far the better.

Applications

Wherever possible, wood-working machines should be driven by alternating-current, squirrel-cage motors. The principal reasons for this are because of the inflammable nature of the material; the direct-current open motor with sparking commutator might be a serious risk because of the large amount of dust and dirt which is always present. There is an additional reason in that wood-working machines are inherently high speed and practically all constant speed, so that a high-speed induction motor is particularly applicable, whereas the same speed on a direct-current motor might cause commutation troubles. Where direct-current motors must be used they should be totally inclosed and compound wound, because under the fluctuating load which occurs with every wood-working machine while it is running under load, compound-wound motors give better service than shunt wound.

Metal-working Machinery

In the case of the metal-working machinery the conditions differ so that no one type of motor can be said to be best suited to all conditions. Dust and dirt are not so prevalent as in wood-working plants and the materials used are not inflammable. The question as to the proper type of motor, therefore, depends largely upon local conditions. Where the tools are small and group driven and where the speeds are not changed frequently, the induction motor offers the advantages previously set forth—simplicity and ruggedness. However, there are many tools, such as large lathes, where the speed is frequently changed and where the output depends largely on the facility with which the operator can adjust the speed to meet the conditions. In such cases the direct-current, adjustable-speed motor is best.

With lathes, boring mills, drills and similar machinery, shunt-wound, direct-current motors and squirrel-cage, alternating-current motors are satisfactory. With planers, rolls, bulldozers, etc., compound-wound motors are more satisfactory if direct current is used and wound-rotor motors if alternating current. With planers, where the horsepower for reversing is much greater than for the actual cutting stroke and for punches, presses and similar machines where violent overloads occur a flywheel should be installed wherever possible.

Pumps

For present purposes pumps may be divided into reciprocating and centrifugal types. In the former the amount of water pumped per revolution of the crankshaft is constant, barring slippage, being due to the positive displacement of the water by a plunger or piston. Any increase in pressure increases directly the work to be done. Where alternating current is used a wound-rotor motor is preferable, where the motor starts under load, and a compound-wound motor where direct current is used.

Rotary pumps are of comparatively small size and may be classed as reciprocating pumps so far as motor application is concerned as they produce a positive displacement of the fluid by means of rotating cams.

In centrifugal or turbine pumps the pressure developed is proportional, theoretically, to the square of the speed, and the volume of water discharged is proportional to the speed; hence the horsepower required varies as the cube of the speed. A reduction in head tends to overload the motor and with some types of pumps the breaking of a discharge pipe close to the pump, for instance, would overload the motor dangerously. A motor to drive a centrifugal pump, therefore, should be large enough to take care of any load thrown upon it by an increase in speed or a decrease in head, and should be protected, either by some protective device or by the design of the pump itself, from excessive overload if the discharge line breaks. Centrifugal pumps require low starting torque and even when running with discharge valve closed require only about 35 per cent. of normal power.

Fans, Blowers and Compressors

Fans are more or less like centrifugal pumps in their action in regard to power requirements. As the head is decreased the power increases, and similarly as the speed increases the power required goes up as the cube of the speed. Hence, it is important to make sure that the operating conditions are thoroughly understood and that the motor is of the proper size. Speed regulation, as in the case of centrifugal pumps, is also important.

Some blowers produce their pressure by means of rotating cams so that their behavior is unlike that of fans since the volume displaced per revolution is fixed regardless of the pressure. Any decrease in pressure decreases the load and *vice versa*. Both fans and blowers start without load.

Compressors of the reciprocating type present no especial difficulty in applying motor drive. Large compressors are often driven direct by synchronous motors with the rotor pressed direct on compressor shaft. In this case the compressor is provided with some form of bypass or unloading device so that no trouble is experienced in starting.

While cases might be multiplied indefinitely showing the application of motors to certain types of machinery yet the foregoing illustrate the way in which these requirements vary, due to the character of the work. In attacking any motor-drive problem the first essential is to know the individual peculiarities of the driven machines, how they operate and just what will be expected of them. The question as to kind of current is determined not only by the machine itself but by the conditions existing at the plant, whether current is to be purchased or generated and whether a choice is available or the kind of current is fixed. From the general conditions of the plant a choice can usually be made as to the general type of motor to install. Then each individual motor drive should be taken up as a separate problem so far as possible. The estimate first made may have to be modified as the work progresses or additional data are given. While it is absolutely essential that a motor should be amply large to handle the work, yet if it is too large the operating efficiency is lower, the first cost greater than it should be and in the case of alternating current the power factor is lowered; hence overmotoring is to be avoided. Furthermore, no matter how well the motor is adapted for the work, it must be properly installed and properly cared for after installation or it will not give satisfaction.

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The machinery building of the Panama-Pacific exposition, at San Francisco, Calif., which was put under construction on Jan. 1, 1913, will be the largest frame building in the world, according to its architect, Clarence Ward. It will require 8,000,000 ft. of lumber, it is stated.

Handy Wiring Computer

Electrical engineers and wiremen will appreciate a handy wiring computer which is being furnished free upon request by the Simplex Wire & Cable Co., of 201 Devonshire St., Boston.

The computer is mounted on stiff, thick celluloid of a convenient pocket size, and consists of a circular slide rule particularly adapted for wiring calculations.

The size of a wire, B. & S. gage, is readily determined by setting the disk to correspond to a given distance of distribution for a desired voltage drop and the current which the wire is to carry; or given the size, B. & S. gage, the current to be carried and the distance of transmission may be found. The resulting voltage drop may be read directly upon the computer. In like manner, the current may be found at one setting for a desired voltage drop with a definite sized wire and distance of transmission. Finally, the distance to correspond to specific conditions of voltage drop, the current, and size of wire may be found by a single setting of the disk. The setting of the disk is very simple and directions for attaining these four different results are given explicitly at the foot of the card. Much laborious figuring is thus avoided by its use. On the reverse side of the pocket card are handy tables of wiring data and a table of decimal equivalents of fractions of an inch.

Reversed Polarity

I was interested in the account of a reversal of polarity, by Mr. Gibbeney in the Jan. 14 issue. No mention was made, however, of the kind of field employed or the nature of the load at the time.

As the machines were not running in multiple and it does not seem from the account that any switch or circuit-breaker had been so suddenly opened as to cause reversal by induction, I assume the generator to have been carrying a motor load and that it had series or heavily compounded fields, possibly running at the time with considerable resistance cut in the shunt field circuit. Under either of these conditions the following explanation, in conjunction with the two diagrams, would explain one likely cause of such a reversal.

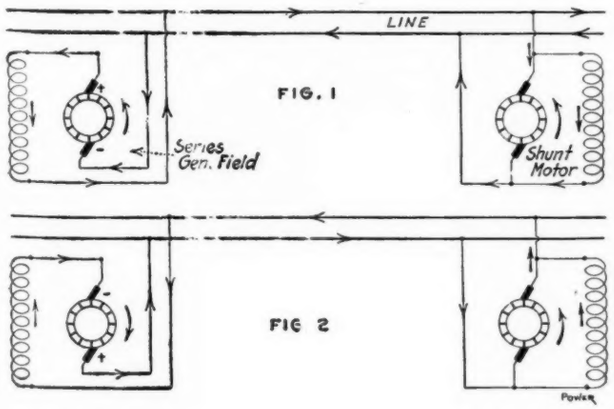

Fig. 1 shows a series generator or the series winding of a compound-wound generator, connected to a shunt-wound motor. Granted a sudden decrease in the speed of the engine as stated, if the nature of the load was such that the momentum of the machines carried the motors over a few revolutions as a generator (say street-car or elevator service), the motors acting as generators would send a current in the reverse direction to the generator and reverse the direction of magnetism in the field and the generator would act momentarily as a motor against the pull of the engine.

It will be noticed from the diagrams that the direction of magnetism in the motor field is not reversed, as would be the case if the reversal of polarity was caused primarily by the generator.

I would like to hear whether the conditions were as assumed in regard to the windings and load.

WILLIAM C. THORNE.

Wineland, N. J.

Voltage across a Lamp

A statement that seems to be believed by many is that when either two 110-volt lamps are placed in series across a 220-volt circuit or five in series on 550 volts, if one of the lamps is removed and something else substituted in its place there will still be 110 volts across whatever has replaced the lamp, no matter what its resistance may be.

The writer once heard such an argument between a dynamo tender, who knew better, and a repairman who did not. They were working in an electric-railway power station, the voltage was about 550. Nevertheless, the repairman insisted that if he removed one of the lamps from a cluster of five in series and himself bridged the gap he would get a shock from only 110 volts.

The dynamo man did not agree with him but was willing to let him make the experiment. The repairman removed one lamp and took hold of the ends of the wires, but dropped them much more quickly than he had taken hold of them, at the same time being nearly knocked to the floor. After that he was willing to believe that the voltage between two portions of a series circuit might vary.

However, there are many who are mistaken on this point. A little thought on the subject, however, will convince anyone that the voltage drop across the different parts of a circuit will vary as the resistance of these parts, and when a man interposes the high resistance of his body between other parts of the circuit made up of comparatively low resistance units he will get the greater part of the drop, and in consquence a much more severe shock than he expected.

The same mistake is often made when an attempt is made to burn incandescent lamps of different resistances, but designed for the same voltage, in series with one another. This happens not only when two new lamps of different candlepower or of the same candlepower but different watts per candlepower are placed in series, but also when a new lamp is placed in series with an old one marked exactly the same. The reason for the trouble in the last instance is that as a lamp gets older and has burned many hours, its resistance changes.

Whatever the cause of the difference in resistance the result will always be the same—the lamp with the higher resistance will get more than its share of the voltage across its terminals and will burn out sooner than would have been the case if all of the lamps had been of the same resistance.

Brooklyn, N. Y. G. H. MCKELWAY.

GAS POWER DEPARTMENT

Observations on the Oil Engine

By John F. Wentworth

In the early days of the internal-combustion engine, illuminating gas was the sole fuel. Although patents in this line date back as early as 1794, the first engine of this type built and run successfully was the Lenoir (1860), which was run like a steam engine. Gas vapor or a mixture of gas and air was admitted for a part of the stroke and then exploded, the expansion of the working charge taking place during the remainder of the stroke. This engine had a very poor economy and was simply an endeavor to apply the explosive-gas idea to the ordinary steam-engine principle.

The next step in the internal-combustion engine was a step backward on the track of the steam engine to the first type built or to the atmospheric engine. This was known as the "free piston" type. There were at least two engines of this kind built—one by Otto and Langen, in Germany (1867), and the other by Barsanti and Mattenecci, in Italy, the former apparently the more successful. Substantially, a charge of air and gas was exploded under a piston in a long water-jacketed cylinder and the force of the explosion propelled the piston upward. The gas expanded to below atmospheric pressure, due to the combined effect of the momentum of the piston and the rapid cooling of the gases caused by their sudden expansion. Upon the return stroke the piston did its work by an ingenious arrangement whereby the rack carried by the piston was thrown into mesh with a pinion upon the shaft. This engine worked, but was too noisy.

Otto next produced the internal-combustion engine in its present form of the four-stroke cycle. Owing to absence from the noise of the rack and pinion this engine was first known as the "Otto Silent."

The distillation of gasoline in the production of kerosene oil, and the fact that gasoline was easily vaporized to form an explosive, led to the use of a carburetor producing an explosive mixture of air and gasoline vapor in place of the mixture of gas and air. This type of engine soon developed to such an extent that what was an almost valueless byproduct from the production of kerosene has now become so valuable as to almost make kerosene the byproduct from the production of gasoline. George B. Brayton was one of the first to foresee this condition of affairs and began to work upon a form of engine in which crude oil could be used for fuel. He and his coworkers attempted to form a mixture of air and oil and treat it in a manner similar to the way in which the gasoline and air was treated, but with poor success. Endeavors have been made to treat the crude oil with heat to vaporize it and form an explosive mixture, but these attempts have all failed, owing to the presence of a nonvolatile portion of the crude oil, which forms a tar and clogs the vaporizing element after the engine has been run a short time. Before the time of Diesel, Brayton had an engine in which the oil was mixed with a jet of air and driven into the cylinder at the end of the compression stroke. It was supposed to be ignited by a sort of burner maintained within the combustion chamber. This burner was fed with oil and had a coil of platinum wire. While some arrangement of this sort might work for a while, it was bound to sooner or later become foul. Had Brayton known of or used the de Rochas cycle with its ignition by the temperature of compression, he would have had no trouble with ignition and Diesel might never have been heard of.

Rudolph Diesel in 1891 applied for a patent in this country, on his now famous engine. He was at first carried away with the idea of preventing the loss of heat by the water jacket. The writer knows how easy it is to fall for this idea because he spent much time and money along similar lines. He hoped to gain by cutting out the water jacket loss and using this energy to heat a larger volume of air, and it was hard to see how anything was lost. It is now clear to the writer, however, without the aid of mathematics; the adiabatic line is the hill. By compression the height of the hill was increased without a change of conditions, for theoretically all that is lost by compression is got back by expansion. This adiabatic line is a smooth curve without a break reaching infinity volume and absolute zero. If heat is added to the substance it is equivalent to adding a layer to this curve, but to get 100 per cent. efficiency all the energy of this layer must be collected even to absolute zero. This type of engine which the writer was working on would be fairly efficient at low pressure.

Dr. Diesel did not fail in his thermodynamics, but he did even worse—he did not take into consideration the loss in mechanical efficiency due to the compression of the air. His engine in mechanical construction was identical with the Brayton engine except that he left off the flame ignition and in its place he followed the principles laid down by de Rochas in 1862. To quote from Dugald Clerk, the operation proposed by de Rochas was as follows:

1. Suction during the entire out stroke of the piston.
2. Compression during the following instroke.
3. Ignition at the dead point and expansion during the third stroke.
4. Forcing out the burned gases from the cylinder on the fourth stroke.

The ignition he proposed to accomplish by the increase of temperature due to compression.

In addition to applying the principle of de Rochas to the Brayton structure, Diesel proposed to eliminate the water jacket and to feed his fuel in such small quantities as to prevent an essential increase in pressure or temperature.

In U. S. Letters of Patent No. 542,846, issued to Rudolph Diesel, July 16, 1895, is found the following:

> According to what has been above stated, the process of combustion itself differs from all the hitherto methods, in that there is no increase of temperature produced, or at the most only a very slight one, and the highest or extreme temperature is produced by the compression of the air. It is therefore under control and will be kept within moderate

limits, and moreover, in view of the cooling of the products of combustion by the subsequent expansion, no artificial cooling is required for the cylinder, the mean temperature of the gases being such that the parts of the engine can be kept tight and lubricated.

In Fig. 1 the diagram *ABCDEA* is from the actual Diesel engine, which has the record of the highest efficiency for any engine ever built with the possible ex-

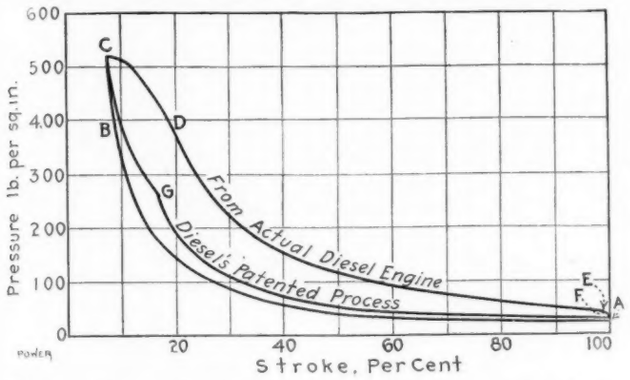

FIG. 1. ACTUAL DIESEL DIAGRAM COMPARED WITH THAT DRAWN ACCORDING TO PATENTED PROCESS

ception of the Banki motor. Diagram *ABCGFA* is plotted according to the patent process. The line *ABC* is the adiabatic compression line; *CG* is the isothermal expansion line and *GF* is the adiabatic expansion line. The feeding of the fuel continues from *C* to *G* at a rate such that there is no essential increase in temperature. By a comparison of the tests published on the Diesel engine as actually run, it becomes evident that the patented process of Dr. Diesel would not give power enough to run the engine. This is so on account of the loss in

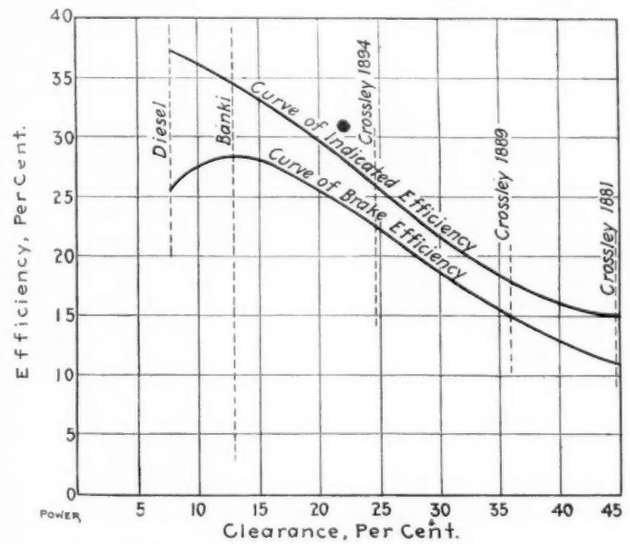

FIG. 2. BRAKE AND INDICATED EFFICIENCIES OF DIFFERENT ENGINES

compressing the air. This ideal diagram (*ABCGFA*) would have a fair theoretical efficiency, but no practical efficiency.

This patented process is disclosed by Claim 1 of the above mentioned letters of patent. The claim reads:

> The herein described process is for converting the heat energy of fuel into work, consisting in first compressing air, or a mixture of air and neutral gas or vapor, to a degree of producing a temperature above the ignition point of the fuel to be consumed, then gradually introducing the fuel for combustion into the compressed air while expanding against resistance sufficiently to prevent an essential increase of temperature or pressure, then discontinuing the supply of fuel and further expanding without transfer of heat.

This is the only process to which Diesel can lay claim as far as the writer can find out. All other patents are combination patents and the best practically copy the Brayton construction.

Sargent originated a method for governing gas engines in which the amount of air was varied to agree with the load as well as to vary the fuel. In the de Rochas cycle and its modifications the ignition of the fuel is controlled or brought about by the temperature resulting from compression aided in some cases by a heated projection in the combustion chamber. In all cases the design of the engine gives compression sufficient to obtain ignition of the fuel. Now if the amount of air is cut down when the load is lowered, ignition will not take

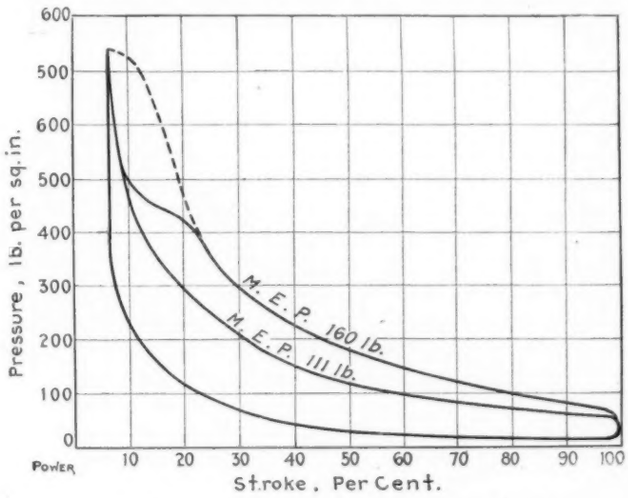

FIG. 3. DIAGRAM FROM WENTWORTH ENGINE

place. Compression of unnecessary air means a loss in mechanical efficiency or the mechanical efficiency of the de Rochas cycle falls off far more at low loads than does the mechanical efficiency of gas engines under the same load.

Fig. 2 shows curves of brake and indicated efficiencies on different engines. The idea of these curves as originally worked up and plotted was to show the benefit of high compression. By running a series of tests on the same engine fitted with different heads so as to vary the clearance, more valuable results could be obtained than to compare different types of engines which had the required range in clearance. However, the curves show the benefit which has come from a development along the lines of a reduced clearance.

Fig. 3 is a diagram taken on the writer's experimental engine. This is not a commercial engine, as yet, and has been designed only for private experiments. There is one point which may or may not mean anything. It seemed to the writer that the Diesel engine was not using as much oil per pound of air as was possible and this diagram perhaps could be taken to verify this belief. The peculiar shape of the diagram may be explained as follows:

The pressure in the air line was about 750 lb. and the fuel was fed in earlier than in the Diesel engine; hence the explosion pressure jumped up so as to stop the

further injection of oil. Then as the charge of hot gases in the cylinder expanded, the pressure in the cylinder was lowered and the fuel was again fed into the cylinder before the fuel valve closed. Whatever the cause was, in the experimental engine a mean effective pressure was obtained about 50 per cent. higher than in the Diesel engine. In fairness to the Diesel engine it is reasonable

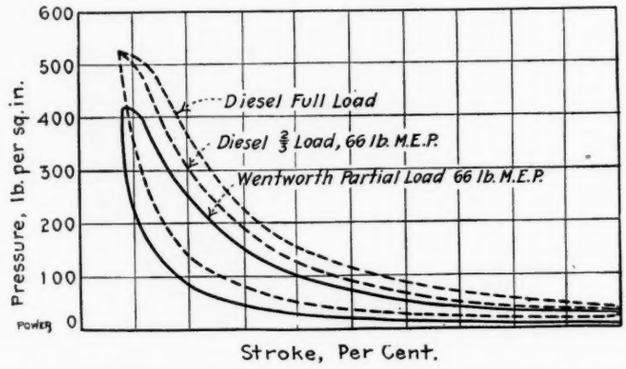

FIG. 4. DIESEL AND WENTWORTH DIAGRAMS COMPARED

to expect that there would have been trouble to have maintained this mean effective pressure without a higher air pressure for feeding the fuel into the cylinder. The dotted lines show what is the most favorable result to be sought for in an engine of this type. This shows one great variation from the Diesel type, which consists of feeding the fuel in, not so as to prevent any essential increase in pressure or temperature, but so as to get the highest explosion pressure practical.

In the preceding paragraphs it has been attempted to show that the Diesel engine is a reproduction of the ideal engine described by de Rochas nearly 50 years ago; de Rochas proposed an engine having full suction stroke, and Diesel carried this into operation, in order to get the desired ignition temperature. Diesel practice shows that about 500 lb. pressure will give an ignition temperature suitable for any fuel. At full load perhaps this is the best that can be done. Practical considerations may make it advisable to refrain from using a pressure of over 500 lb. per sq.in. in the cylinder. The main point of the writer's work has been to produce a crude-oil engine in which an ignition temperature of suitable amount can be obtained with a full cylinder of air or a partial cylinder of air.

The Diesel engine is supposed to operate in any temperature, but the writer has never seen anything relative to the climate in which it can be used. If the Diesel engine has a temperature of compression of 1000 deg. F. with outside air at 60 deg. F. (which temperature is satisfactory), if operated with the outside air at 120 deg. F. the temperature of compression would be 1100 deg. F. or at least 100 deg. more than is required. Likewise, if the intake air should drop to 0 deg. F., the temperature of compression would drop to 885 deg. F.

The Wentworth engine is different from the Diesel in that provision is made for heating the incoming air before compression. If this is done with intelligence it is possible to have the temperature of compression correct and to have the proportion of fuel to air constant at all loads. The Diesel engine governs by varying the fuel only; the Wentworth engine by varying the fuel and air so as to keep the mixture constant and in order to have, at 250 lb. pressure of compression, the same temperature which is had at 500 lb. pressure, heat is added to the incoming air.

Fig. 4 shows a full-load and partial-load diagram from the Diesel engine, shown dotted, and the solid line is a partial-load diagram as is sought in the Wentworth engine. The full-load diagram of the Wentworth engine would lie somewhere between the full-load Diesel diagram and that shown in Fig. 3. The advantage of the Wentworth engine over the Diesel or any other engine which governs by a reduction of the fuel alone or by varying the proportions of the mixture is shown in Fig. 5. Here curves are drawn by laying off at regular intervals the pressure per square inch on the piston for every 36 deg. revolution of the crankshaft. This shows that the Diesel engine at two-thirds load would have an average pressure on its bearings, due to 145 lb. per sq.in. in the cylinder. The Wentworth engine developing the same power would have a pressure on its bearing from but 98 lb. per sq.in. pressure in the cylinder. This would show a saving on the main bearings of 33 per cent. In this method of treating the subject, which is simple and graphic, no allowance is made for the effect of the reciprocating parts. At the same speed the two engines would have the same pressure on the bearings from this source.

At partial load the Wentworth engine is virtually a compound engine. On the compression stroke but two-thirds or three-quarters of a cylinderful of air would be compressed, while on the expansion or working stroke the expansion would be carried out the full stroke. Assuming that the engine was running on two-thirds power or that two-thirds the amount of both fuel and air was used, the effect of compounding would be equivalent to the present Diesel engine compressing its charge in a cylinder of 28 in. diameter and expanding in a cylinder of 35¾ in. diameter. This gain in the theoretical efficiency can be obtained without any loss whatsoever. Opponents of this theory say it involves a bulky engine; that is, that by heating the air before compression in order to raise the ignition temperature, more than two-thirds of the cylinder capacity of the Diesel engine will be required to get two-thirds of the weight of air which the Diesel engine uses at full load. This is true only when the engine is running light; however, the writer has it on authority that the Diesel engine can run on a reduced compression after the engine becomes warmed, or in other words, compresses to a higher pressure than is needed after the engine gets started. In the Went-

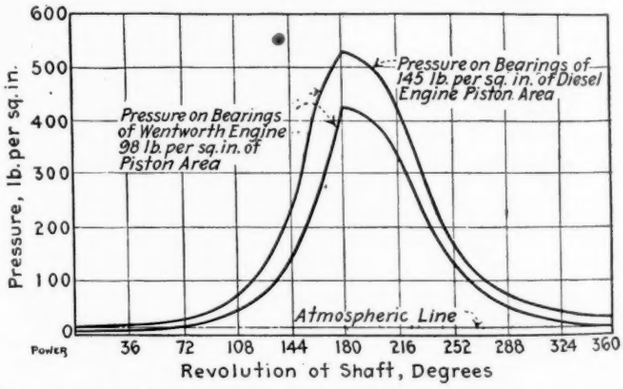
600
500
400
300
200
100
0
Pressure, lb. per sq. in.
POWER
Pressure on Bearings of 145 lb. per sq. in. of Diesel Engine Piston Area
Pressure on Bearings of Wentworth Engine 98 lb. per sq. in. of Piston Area
Atmospheric Line
36 72 108 144 180 216 252 288 324 360
Revolution of Shaft, Degrees

FIG. 5. RELATIVE BEARING PRESSURES OF DIESEL AND WENTWORTH ENGINES

worth engine by a regulation of the temperature unnecessary compression can be saved.

The recommended Wentworth cycle is as follows:

1. Addition of heat to the incoming air to give a temperature such that when the desired compression pressure has been reached ignition will be possible by the simple injection of the fuel.
2. Suction for that part of the suction stroke which will compare with the load upon the engine.
3. A full compression stroke.
4. Ignition to be obtained by injection of the fuel. (In light loads this injection of the fuel will be advanced in order to give a higher pressure of explosion.)
5. A full expansion stroke.
6. A full exhaust stroke.

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Lubrication of Gas Engine Cylinders

In reading the article on the above subject in the Jan. 28 issue, by A. L. Brennan, Jr., I found several passages which are not clear to me, and others with which I cannot agree.

It is stated that there are three important points to be considered in the lubrication of a gas-engine cylinder; these three qualities of the lubricating oil being a flash point of 390 to 450 deg. F., a specific gravity of from 26 to 30 Bé., and a viscosity ranging from 180 to 220 at 80 deg. F. According to Mr. Brennan, viscosity is made up of two properties; cohesion and adhesion. He says the former "is that property of the oil that binds its particles together," and that "adhesion is that clinging property which causes it to adhere to other bodies." It may be that the viscosity of an oil is made up of two, or maybe twenty properties, but it is usually measured by noting the time taken for a given quantity of oil to run through a given size aperture in an instrument which is usually known as a viscosimeter. It is really a measure of its fluidity. Mercury, for instance, has a very low viscosity, but relative to many bodies, no adhesion.

No general rules or principles can be laid down which can be applied to all types and sizes of gas-engine cylinders. Lubrication of small gas and gasoline-engine cylinders, such as used in automobiles and motor boats, is a comparatively simple matter, and, even though an oversupply of lubrication fouls the cylinders, the cleaning of them is comparatively easy. When it comes to large cylinders and especially large cylinders in a horizontal position, the problem is vastly different. I am quite sure that Mr. Brennan had not the latter condition in mind, but the lubrication of large horizontal cylinders presents the real problem in gas-engine lubrication. Moreover, I am convinced that some of the cheapest oils I have purchased and used (18c. per gal.) have proved as effective and satisfactory for lubricating large gas-engine cylinders as any others.

The qualities of any mineral oil under high temperatures are vastly different than at ordinary temperatures and pressures, such as that of the atmosphere in which they are tested, and indeed all mineral oils approach each other in physical characteristics at high temperatures. It has been conclusively shown that out of over 200 oils tested, ranging in specific gravity from 0.887 to 0.926, some of which were too thick to flow at 70 deg. F., and having viscosities ranging from 58 to 312 at 212 deg. F., nearly all of them had the same viscosity at temperatures above 500 deg. F. The flash points of these oils ranged from 288 deg. F. to 622 deg. F. These tests show, that with the conditions under which most oils operate in a gas-engine cylinder, if temperatures alone are considered, they all have practically the same viscosity.

Nobody knows just what the physical action is which takes place during processes of lubricating a gas-engine cylinder. It is pretty generally supposed that the condition which makes lubrication possible is the comparatively low temperature of the cylinder walls and the piston. It must be evident that any combustible which is in a cylinder during an explosion stroke, is at least partially burned. If the interior surface of the cylinder walls and the head of the piston is at such a temperature that combustion on the surface is quenched, then any oil that may be on this surface may be partially burned. That portion of the oil which is not burned in the combustion space is, however, usually incombustible matter. It is important that the oil should contain no incombustible matter if the cylinder is to be kept as free from carbon as possible. It is expected that some oil may find its way into the combustion space, but it is the hope of most operators that such oil will burn up without depositing on the walls.

The splash system of lubrication is a "makeshift" in anything but small motors, in which it may be used quite effectively. The lubrication of large cylinders is usually done by timing the delivery of the lubricant under pressure so that it enters between the rings on the piston.

Mr. Brennan says that "the first indications in the case of using a poor oil are manifest in decreased power, due primarily to the friction offered the surfaces of the piston and cylinder, secondly, to faulty compression, due to the piston rings becoming inoperative, and thirdly, to carbon deposits, which materially reduce the efficiency of the valves and impair the function of the spark plug."

Unless an engine is staggering under all the load it can carry, I have yet to see one in which I could discover a case of improper cylinder lubrication by a decrease in the power developed. Usually the governor will open up and allow the engine to pull all the load demanded unless some other conditions than faulty lubrication exist; such, for instance, as weak gas, missed ignition, etc. I am convinced that if cylinder lubrication were so much at fault that one could notice it by a decrease in power, there would be some smoke and probably the piston would seize before the keenest eye could discover a decreased power development.

Mr. Brennan is correct in saying that one of the most injurious effects of improper lubrication is the deposit around and under the piston rings, which soon renders them inoperative as spring rings and practically fastens them in their grooves. Such a condition is one of the most prolific causes of cut and scored cylinders. But in many such instances which I have seen, I am quite sure that the contributing cause is dirty gas.

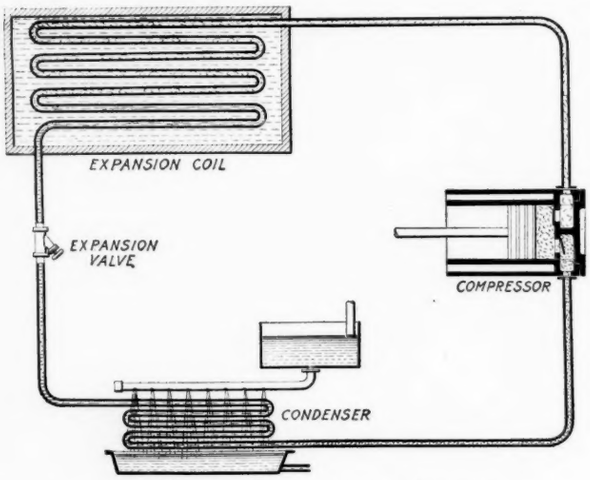
I would appreciate being informed as to just what is meant by this sentence—"Poor lubricating oil not only impairs the mixture by a partial combustion of its own elements but by not keeping the wear at a minimum, allows lower compression which in turn puts greater demands upon the ignition current." Especially is it desirable to know how lower compression puts greater demand upon the ignition current.

New York City. L. L. BREWSTER.

REFRIGERATION DEPARTMENT

Refrigeration Made Simple

Refrigeration has been defined broadly as the process of cooling. A block of ice in the small refrigerator for home use is commonly supposed to cool down the interior of the box in which it is contained, and so it does, but instead of imparting cold to its surroundings, the cooling effect is obtained by the ice extracting heat from the air, the material of which the refrigerator is made and the food contained within. In doing this it melts, and when enough heat has been drawn from the refrigerator all of the ice will have been turned into water. Refrigeration then is the process of extracting heat, and will always take place when a cold body is in the presence of another at a higher temperature. If the hand is placed in a pail of water fresh from the well, a flow of heat will take place from the hand to the water. The hand will have lost the same amount of heat that the water has gained, and as it has been made colder, that is, as heat has been extracted from it, the hand has been refrigerated and the water is the refrigerant. Just as water will always flow from a higher to a lower level so will heat pass from any material to one of lower temperature. It is this action which makes refrigeration possible.



AMMONIA COMPRESSION SYSTEM

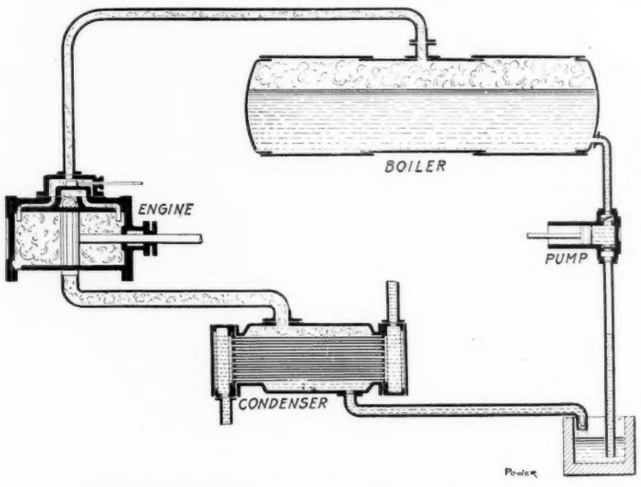


DIAGRAM OF CONDENSING STEAM PLANT

It is evident then that any material may refrigerate, provided that it is at a lower temperature than its surroundings. The water in a tubular boiler refrigerates the gases passing through the tubes, although it is not commonly thought of in this way, as it is usual to link refrigeration with lower temperatures.

There are a few materials, however, due to their peculiar properties, by which refrigeration may be more efficiently effected. Most prominent of these are ammonia, carbonic-acid gas and sulphur dioxide. Ammonia is more commonly used than the others and in two different types of apparatus, which collectively are known as the compression and absorption systems. Compression plants are much more numerous, and to understand their working, a comparison will be made with the ordinary steam plant with which all of us are familiar.

In the accompanying sketch a rough diagram of the steam plant is shown on one side and the compression system of refrigeration on the other. From the drawing it is easy to see that the two systems are similar. In fact, they are governed by the same laws, but the events in each cycle are in the opposite direction. To begin with, the water in the boiler is supplied with heat from the coal burning on the grate. Only one heat unit to a pound of water is required to raise the temperature 1 deg. F. As a consequence the rise in temperature is rapid until 212 deg., the boiling point at atmospheric pressure, is reached, when it appears to stop and no further rise may be noticed until 970 heat units, known as the latent heat of evaporation, have been added to every pound of water. When this heat has been absorbed the water turns into steam, and if the steam is not allowed to escape the pressure will rise. The minute that pressure is developed a funny thing happens. The boiling point of the water is no longer at 212 deg., but at some temperature corresponding to the pressure. If the pressure were 150-lb. gage, the water would boil, or, in other words, evaporate, at 366 deg., and the latent heat would be reduced to 857 heat units. Any temperature below 366 deg. would condense the steam.

From the boiler the steam passes to the engine, where it expands and gives up some of its energy in the form of work. Passing on to the condenser enough cooling water is supplied to condense the steam, and the water of condensation is returned by means of a pump to the boiler. This pump requires a certain amount of energy to drive it, and to obtain the most economical results the water should be returned to the boiler as hot as possible.

In the refrigerating system we will start with the expansion coils, the part of the system corresponding to

the boiler. Here the liquid, the ammonia, is introduced and evaporated by the heat from its surroundings. If the ammonia coils are placed directly in the room to be cooled, the process is known as direct expansion, but if the coils are located in a brine tank and the brine circulates in the room we have the brine system. From the expansion coils the ammonia vapor is drawn into the compressor and instead of expanding and producing work, as in the steam engine, the vapor is compressed, which requires an expenditure of work. If the boiling point of ammonia at the expansion-coil pressure were at some temperature higher than the temperature of average cooling water, there would have been no need of the compressor. At atmospheric pressure the boiling point is 28 deg. below zero and cooling water is usually 60 deg. above and over. So it is necessary to compress the vapor to about 185 lb. pressure to raise its boiling point so there will be no difficulty in converting the vapor into liquid in the condenser, to which it passes from the compressor. Although generally of different construction, the ammonia condenser operates on the same principle as the steam condenser.

In its liquid state the ammonia passes from the condenser through a restricted opening, called the expansion valve, to the expansion coils. In an ideal system the expansion valve might be readily replaced by a cylinder so that the liquid in passing from a higher to a lower pressure would do work, and not require an expenditure of work as in the case of the steam pump. The temperature of the liquid should be as low as possible, which, it will be remembered, is a requirement just opposite to that in the steam system.

When the ammonia liquid now at a low pressure, usually about 16-lb. gage, enters the expansion coils in the refrigerator, it absorbs heat from the surrounding medium, and when each pound of liquid has absorbed 569 heat units the latent heat at the above given pressure, it is converted into a vapor and is ready to start over again on the cycle just described.

From what has been said it will be clear that the prime object of a steam plant is to obtain as much work as possible with the least expenditure of heat, while in the refrigerating system it is desired to absorb or rather dissipate as much heat as possible with the least expenditure of work.

If the latent heat of the ammonia were 970, as in steam at atmospheric pressure, it would be a better refrigerant, as per pound it would carry away more heat from the refrigerator. Thus high latent heat is desirable in a refrigerant. Another requirement is a low boiling point, as this must be lower than the temperature it is desired to maintain in the refrigerator. On the other hand, the boiling point should not be much lower than the refrigerator temperature, as the lower it is the more power it will take to compress the vapor and raise the boiling point to a temperature above that of the cooling water in the condenser.

Ammonia seems to meet these requirements better than any other refrigerant. The most simple refrigerating plant imaginable would be a flask of ammonia liquid immersed in a pail of brine which we will say has a temperature of 50 deg. As previously stated the boiling point of ammonia is 28 deg. below zero, so that the temperature of the brine will be 78 deg. higher. Consequently, the ammonia will immediately begin to boil and evaporate, drawing the necessary heat from the brine until its temperature approaches that of the boiling ammonia. The brine in turn would tend to absorb heat from the surrounding air, so to maintain a low temperature in the pail it would be necessary to replenish the flask and continue the evaporation of ammonia, allowing the vapor to escape to atmosphere as before. This would be all right if the supply of ammonia were inexhaustible and it were not an expensive product. Unfortunately, this is not the case and it is necessary to conserve the supply, using it over and over again in much the same way as boiler-feed water.

To reclaim the ammonia vapor and change it back into a liquid, the compressor and condenser are necessary, in fact, just such a system as outlined in the sketch. There are, of course, auxiliary apparatus required just as in a steam plant, but the main principles of operation are pictured. The details of an actual commercial plant may be given in a later issue.

Drinking Water Systems

By S. M. Weinthal

To circulate pure, cold water through a large structure is not a new idea, as many hotels and buildings in large cities have been so equipped during recent years. From a sanitary and humanitarian standpoint, these drinking-water systems are a necessity and should be installed wherever the welfare of employees is considered.

Fig. 1 shows a typical layout of a drinking-water system as applied to a mill or factory; the arrows denoting the path of the water. The water may come from any available source, such as wells, springs, city lines, etc., and, if not deemed sufficiently pure, should be passed

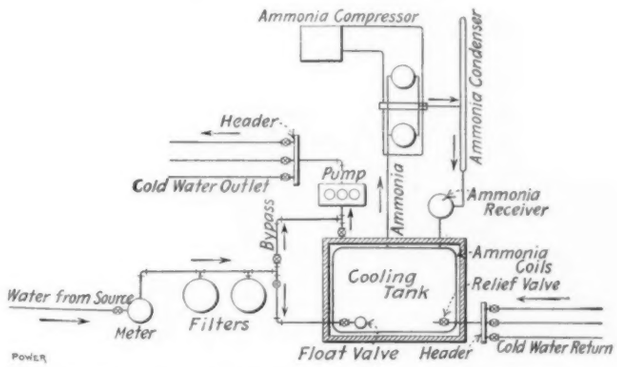


Fig. 1. Typical Layout of Water-cooling System

through a filtering process. It is then received into a storage tank, where it is cooled by contact with the surface of coils cooled by the direct expansion of ammonia, or the circulation of cold brine.

By means of a power-driven pump, the water is drawn from the tank and kept in rapid and constant circulation through the lines, which are arranged to make a complete circuit. These lines should be carried on trusses, hangers and columns and sloped in order to drain. They may issue from and return to headers which are directly connected to the tank and pump respectively. The water used is replaced automatically by water coming from the source.

The maximum length of a circuit should not be greater

than 7500 ft. and the time consumed for the water to travel that distance should not exceed 30 min.; so as to minimize the loss of temperature, which, in that period, averages from 4 to 6 deg. F. if the lines are well insulated.

During the period of cold weather, when it is not necessary to cool the water, a bypass may be provided, as shown in the drawing, to enable the direct passage of the water into the lines. However, this is not advisable if applied at a low pressure, as it must be kept in rapid motion to prevent freezing.

that the most agreeable temperature of the drinking water is 45 deg. F. and the consumption of water per man per hour, including waste, during periods of extreme heat averages 0.3 gal. in factories and 0.4 gal. in mills. On this basis, a mill employing 1200 men would require 480 gal. per hour.

From the accompanying table the capacity of a refrigerating machine can be readily determined when the number of gallons to be consumed per hour has been fixed and the difference of the temperature is known.

CAPACITY OF REFRIGERATING MACHINES TO REDUCE TEMPERATURE OF WATER

Ice Melting Effect—Tons per 24 Hours

Reduction of Temp. Deg. F.	Gallons of Water per Hour														
	1	50	100	150	200	250	300	350	400	500	600	700	800	900	1000
1	0.0007	0.035	0.069	0.104	0.139	0.174	0.208	0.243	0.278	0.347	0.417	0.486	0.556	0.625	0.695
5	0.0035	0.174	0.347	0.521	0.695	0.869	1.042	1.216	1.390	1.737	2.085	2.432	2.780	3.127	3.475
10	0.0070	0.347	0.695	1.042	1.390	1.737	2.085	2.432	2.780	3.475	4.170	4.865	5.560	6.255	6.950
15	0.0104	0.521	1.042	1.564	2.085	2.606	3.127	3.649	4.170	5.212	6.255	7.297	8.340	9.382	10.42
16	0.0111	0.556	1.112	1.668	2.224	2.780	3.336	3.892	4.448	5.560	6.672	7.784	8.896	10.01	11.12
17	0.0118	0.591	1.181	1.772	2.363	2.954	3.544	4.135	4.726	5.907	7.089	8.270	9.452	10.63	11.81
18	0.0125	0.625	1.251	1.876	2.502	3.127	3.753	4.378	5.004	6.255	7.506	8.757	10.01	11.26	12.51
19	0.0132	0.660	1.320	1.981	2.641	3.301	3.961	4.622	5.282	6.602	7.923	9.243	10.56	11.88	13.20
20	0.0139	0.695	1.390	2.085	2.780	3.475	4.170	4.865	5.560	6.950	8.340	9.730	11.12	12.51	13.90
21	0.0146	0.730	1.459	2.189	2.919	3.649	4.378	5.108	5.838	7.297	8.757	10.22	11.68	13.13	14.59
22	0.0153	0.764	1.529	2.293	3.058	3.822	4.587	5.351	6.116	7.645	9.174	10.70	12.23	13.76	15.29
23	0.0159	0.799	1.589	2.398	3.197	3.996	4.795	5.595	6.394	7.992	9.591	11.19	12.79	14.39	15.89
24	0.0167	0.834	1.668	2.502	3.336	4.170	5.004	5.838	6.672	8.340	10.01	11.68	13.34	15.01	16.68
25	0.0174	0.869	1.737	2.606	3.475	4.344	5.212	6.081	6.950	8.687	10.42	12.16	13.90	15.64	17.37
26	0.0181	0.903	1.807	2.710	3.614	4.517	5.421	6.324	7.228	9.035	10.84	12.65	14.46	16.26	18.07
27	0.0188	0.938	1.876	2.815	3.753	4.691	5.629	6.568	7.506	9.382	11.26	13.13	15.01	16.89	18.76
28	0.0195	0.973	1.946	2.919	3.892	4.865	5.838	6.811	7.784	9.730	11.68	13.62	15.57	17.51	19.46
29	0.0202	1.008	2.015	3.023	4.031	5.039	6.046	7.054	8.062	10.08	12.09	14.11	16.12	18.14	20.15
30	0.0208	1.042	2.085	3.127	4.170	5.212	6.255	7.297	8.340	10.42	12.51	14.59	16.68	18.76	20.85
31	0.0215	1.077	2.154	3.232	4.309	5.386	6.463	7.541	8.618	10.77	12.93	15.08	17.24	19.39	21.54
32	0.0222	1.112	2.224	3.336	4.448	5.560	6.672	7.784	8.896	11.12	13.34	15.57	17.79	20.02	22.24
33	0.0229	1.147	2.293	3.440	4.587	5.734	6.880	8.027	9.174	11.47	13.76	16.05	18.35	20.64	22.93
34	0.0236	1.181	2.363	3.544	4.726	5.907	7.089	8.270	9.452	11.81	14.18	16.54	18.90	21.27	23.63
35	0.0243	1.216	2.432	3.649	4.865	6.081	7.297	8.514	9.730	12.16	14.59	17.03	19.46	21.89	24.32

Pipe and fittings should be galvanized and insulated with cork 1½ in. thick, or some other covering of that equivalent. Long-radius ells or pipe bends should be used throughout to lessen the friction and, at points where it is desired to place a fountain, the connection should be as near the circuit as possible, so as to eliminate "dead ends." All waste water should flow directly into a sewer.

The refrigerating machine may be of the absorption or the compression type, the latter being generally used, due to the diversified manner in which it may be driven.

Investigation of some of the plants in operation shows

For example, suppose it is desired to know what size of refrigerating machine is necessary to cool 500 gal. of water per hour from 70 to 45 deg. F. The difference in temperature is 25 deg. In Column 500, opposite a reduction of temperature of 25 deg., read 8.687 tons ice-melting effect. The efficiency of the refrigerating machine will vary with the suction and condenser pressure; but, if these are maintained at the usual figures of 15 and 185 lb., respectively, it will lie between 75 and 80 per cent. Assuming 75 per cent. efficiency, the standard rating of the compressor would be 11.6, or, say, 12 tons.

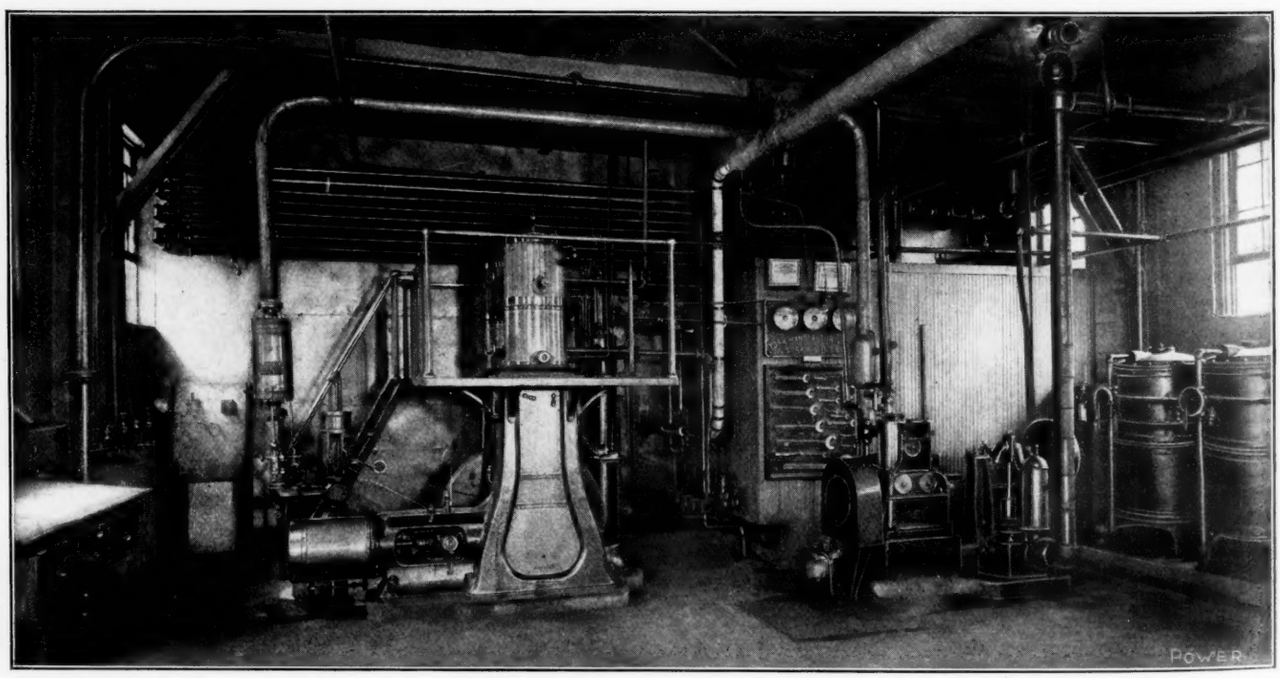


FIG. 2. TEN-TON PLANT AT CONTINENTAL WORKS OF NATIONAL TUBE CO., COOLING DRINKING WATER FOR 1500 MEN

EDITORIALS

In Massachusetts

Massachusetts has the distinction of having adopted the most comprehensive and far-reaching measures controlling boiler inspection and the licensing of engineers. So generally have these laws been approved, that Ohio took them as a pattern for its own laws and all states since and now contemplating legislation along similar lines are closely studying the Massachusetts enactments.

That there is need of state supervision in the matter of the sort of steam-generating equipment that shall be permitted to operate and the character of men allowed to have charge of steam plants, is beyond question. Safety of the public alone is a sufficient consideration, and if they could all only realize it, as some of them do, it is quite as much to the interest of owners and operators that the state shall require all possible precaution against power-plant accidents.

An owner who, unwittingly or from false ideas of economy, would maintain an unsafe boiler or employ an incompetent engineer, should be protected from his own ignorance or folly. The same is true of any engineer, who, lacking laws to prevent, might be required to use an unsafe boiler, or be tempted to take charge of equipment he was unqualified to handle. Generally, it is the very ones most benefited who are the most active in opposing the adoption of laws, and, failing in that, their enforcement. For all the world like a headstrong child, they rebel against the discipline that is for their own best good. And such is the case in Massachusetts if the newspaper reports are authentic.

A representative of the legislature, with more thought for votes than for the value of human life and property, is seeking popular favor by introducing a bill to set aside the requirement that a first-class engineer be employed to operate plants of more than 1400 horsepower. He would have second-class men or those with special licenses take charge of such plants.

Equally misguided are those in another part of the state who have complained of a state boiler inspector who took his duties seriously and, believing that laws were meant to be enforced, was so untactful as to swear out warrants for the arrest of violators of the inspection law. The whine is that his prosecution is persecution, and it is said the inspector has had a tip from "higher up," that, if he desires to remain in his present capacity, it would be wise for him to be more moderate in the enforcement of the laws.

Without knowing the details, it may be granted as conceivable that the inspector is abusing his authority. Some public officials have taken advantage of their power to serve their own ends. It is hardly likely in this case that graft could be the motive or the "persecuted" parties would not have had to go "higher up." Moreover, the newspaper account states, "in most cases the courts have found in his (the inspector's) favor." The account further states that the inspector was threatened by those he prosecuted that influence would be brought to bear to have him removed from the position. We rejoice that thus far he has not been intimidated.

It is unfortunate that the papers printing the reports referred to have such headings as, in the first case, "Measure to Help Engineers," and, the second, "May Trim Sails of the Boiler Inspector." The first looks like deliberate misrepresentation in behalf of the local plants that would like to have cheaper engineers and the second is similarly partisan.

Fortunately, the bias of the daily press is likely to have little effect. The important thing is for the State of Massachusetts to remember that the eyes of the country are upon it and its responsibility is great. Failure of the laws initiated by that state will be of very far-reaching effect and mean a setback to legislation contemplated in many other states. Now, would seem the propitious moment for all engineers' asociations to express themselves by resolutions and official letters where they will do the most good, urging that no part of the present laws be repealed, but that all parts be strictly enforced, for, otherwise, the best law is useless.

Steam Stuff

Some weeks ago we called attention to the desirability of a generic term for the working fluid of a steam engine. H_2O, with which the engine is operated, may come into it as superheated steam, and be exhausted as a mixture of some eighty to ninety per cent. steam, and ten to twenty per cent. water. Our editorial set forth that one could not properly speak of this operating fluid as steam, when it was part water, and it is frequently necessary to make the distinction. We enumerated the terms such as "steam stuff," "working mixture," "operating fluid," "medium," etc., which have been applied to it, and asked for suggestions for a concrete and comprehensive generic name for the stuff.

The readers of POWER are always ready to take a shy at anything, even at language building. Several suggestions have been already published in our correspondence columns. A letter before us suggests as especially helpful, if adopted, to the European people, the euphonic term "venavivacqua," which being interpreted means "a vena with life and water," or "vaporpartevivo," which signifies in the language of sunny Italy, "vapor partly alive."

Another contestant has gone to the Greeks for his, and evolved the cognomen "hydrotherm." He explains that steam may be superheated, dry saturated or wet; there may be moisture present with superheated steam and with saturated steam, there may be also entrained moisture, which is not actually mixed with the steam; that any case when analyzed is bound to be nothing more than heated water, and that the term "hydrotherm" covers each and everyone of the states of condition of water and steam.

Another suggests that it be called "fog" or "vaporol."

Still another correspondent, looking over a copy of

Parker's "Natural and Experimental Philosophy," published in 1856, was struck with the statement that matter exists in four different states, namely, the solid, liquid, gaseous and the vesicular form. The latter seemed to be a specialty of Mr. Parker's, as most other authors stopped their enumeration of the states of matter with three. He defines it as that form of matter in which we see it in clouds. It consists of minute vesicles somewhat resembling bubbles, and it is the state into which many vapors pass before they assume a fluid condition. Water, for instance, is solid in the form of ice, fluid as water, in a gaseous state when converted into steam, and vesicular in the form of clouds. Our correspondent suggests that while the term "vesicular steam" cannot be considered as a name for the composition H_2O in all its conditions, it would be much more definite for designating the composition when in the condition referred to in the editorial than such inexpressive terms as "mixture," "steam stuff," etc.

An analysis of the last paragraph will reveal the need which we emphasize. Several lines above it is said, in the language of our correspondent and probably of the author whom he was quoting, "Water, for instance, is solid in the form of ice," etc. It is not, for when H_2O becomes ice it is no longer water. H_2O in its solid form is ice, in its liquid form water, in its vaporous or gaseous form steam. What we want is a word for the symbol H_2O in this expression simpler than the chemical name hydrogen-oxide.

Glenlyon Economizer Explosion

The coroner's jury in the case of the two men killed by the explosion of an economizer at the Glenlyon Dye Works, Saylesville, R. I. (see POWER, Jan. 28, page 136), has found that the two men "came to their death by accident and misfortune" without obtaining any additional light upon the cause and the manner of the disaster.

It is generally conceded that the explosion occurred in the section of the economizer which had been shut off for the renewal of one of its tubes. Water may have been left in the idle economizer or leaked back from the boilers or in from the feed pipe. With water in the economizer, an inoperative safety valve, and enough gases passing the dampers to even a little more than supply the convection and radiation losses, an explosion would be inevitable, and this is probably the way it occurred. There are those, however, who attribute it to an explosion of gas in the gas passage of the economizer, which had an aggregate volume of some 1800 cubic feet.

Such an explosion is possible, but there is a lack of information as to contributing circumstances to enable us to judge of its probability in this case.

If idle boilers or boilers with heavily banked fires were connected through the economizer it is possible that their furnaces, acting as producers, may have given off gas rich enough in carbon monoxide to produce an explosive mixture, but the coroner finds that "the firing of the boilers was no different than at other times."

It is probable that no definite and satisfying explanation of the cause will ever be found. The lesson to be learned is that water in an economizer subjected to heat will generate pressure and if the usual outlet to that pressure through the boiler is cut off, the pressure may increase to that corresponding with the temperature to which the water may become heated. When the economizer is in operation and connected to the boilers there is nothing for the safety valve to do, for if the pressure in the economizer gets to be greater than that in the boilers it will relieve itself into them. When this connection is closed there should be another positively open which will relieve any pressure which may be generated in the economizer. In case the economizer is to be laid off for inspection or repairs it should be drained of water and the blowoff valve and air vents left open. In order to avoid any possibility of an accumulation of gas in the gas passages the soot-pit doors and such other openings as are available should be left open to permit the free circulation of air.

With these simple precautions an economizer is nowhere nearly as likely to explode as is a boiler, as is evidenced by the remarkably few explosions which have occurred among the large number of economizers in use in all kinds of service.

The Average Owner

On page 350 we print a letter taking exception to our editorial on "The Average Owner," in the Dec. 31 issue. We feel it a duty to hold our columns wide open to the opinions of those who disagree with us, which is the principal reason we print the letter in question. Another reason is that we may hold it up as a horrible example of what we do not like to use, as explained in the editorial "Being Contented" in the Oct. 15, 1912, issue.

This is no reflection on the writer of the letter, for his views are probably justified by his experiences. We still believe, however, that the owner he pictures is the exception, not the average. We do congratulate Brother Robinson for having written one of the neatest gems of sarcasm and pessimism that we have read in a long time. While entirely disagreeing with his opinions, we thoroughly appreciated the letter judged as a piece of composition.

What Vacuum?

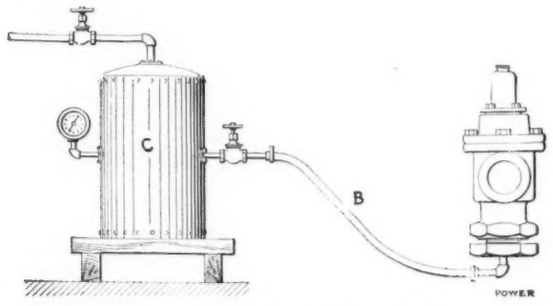
D. M. Morrison, the Scotch condenser builder, who pointed out some time ago that in reciprocating marine installations the highest attainable vacuum is not synonymous with overall economy, now gives expression to his opinion that the value of a vacuum of over twenty-eight and one-half inches for marine turbines is becoming, under many conditions, open to question. Almost everything in engineering is a compromise, and while on the one hand you may have a fair percentage of improvement in the steam consumption, on the other hand you have to consider the increased circulating-pump consumption, the increased weight and space for air and circulating pumps, the increased weight and space of the main condensers, the effect of reducing hotwell temperature, and the increased weight and space of the low-pressure turbines to satisfactorily utilize the high vacuum. It is possible, therefore, that we may come in the end to regard a practical limit in the reduction of back pressure as desirable, even for turbines.

READERS WITH SOMETHING TO SAY

Testing Springs for Pop Safety Valves

Recently I had to take out two locomotive pop-safety valve springs and replace them with lighter ones that were to carry only 30 lb. pressure. Not knowing the formula to find the right size of wire to make a spring capable of yielding at a given load, I used the testing arrangement shown. This outfit is home-made, consisting chiefly of fittings and a small tank found about the plant.

The procedure for testing these springs was as follows: I made a brass plug *A* to fit the safety valves which were also provided with ¼-in. nipples so that connection to an air hose could be made. The tank *C* was subject



EQUIPMENT FOR TESTING SAFETY VALVES

to air pressure at 100 lb. taken from the main air receiver. A gage was fitted to this tank so as to register the pressure within it. For testing the springs, air at 30 lb. pressure was admitted to and maintained in the tank, then, holding this pressure in the tank, the pop valves were set to operate at this pressure. This is perhaps one of the simplest ways to test springs and set such valves. The gage attached to the tank should, of course, be accurate.

JAMES C. MATTISON.

Vancouver, B. C.

First Aid in the Engine Room

There are steam plants in which not so much as a roll of cotton bandage can be found in case of injury to an employee. Every plant, no matter how small, should have something on hand for cuts, burns or more serious accidents. One can make a small cabinet in which such emergency supplies can be stored as peroxide of hydrogen, creoline, capsicol, unguentine, adhesive tape, one package of absorbent cotton and bandage tape; a pair of scissors and a Red Cross emergency instruction book.

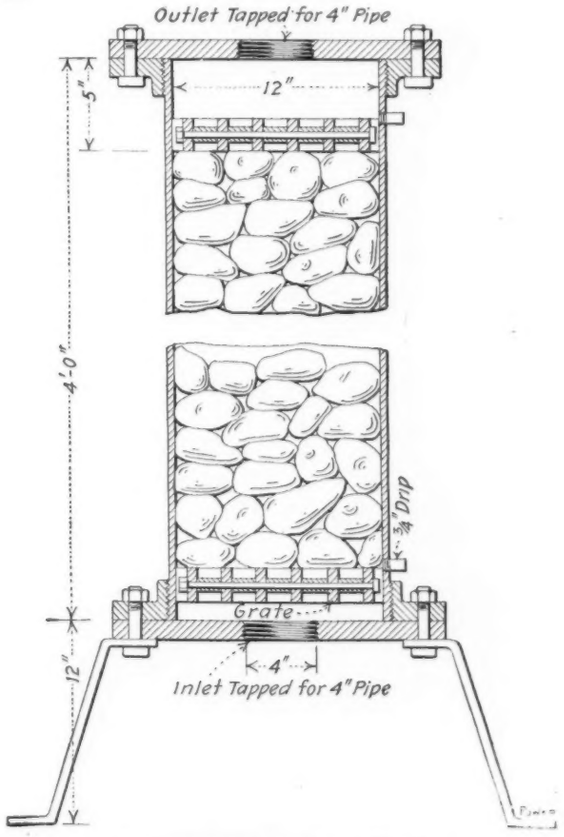
A first-aid kit for treating electric shocks and burns should contain one bottle of spirits of ammonia; one bottle of picric acid; a tin cup; a pair of tongue pliers; a towel; one package each of antiseptic cotton and antiseptic bandage; a roll of adhesive tape; a pair of scissors and an instruction book on the first aid in case of electric shocks and burns. A chart should be hung on the wall in full view of the employees, showing how to induce artificial respiration, and every man in the plant should be taught the procedure.

A. LAMARINE.

New Bedford, Mass.

Compressed Air Dust Filter

After setting up an air compressor in the vicinity of an ore-reducing plant it was found that ore dust was drawn through the compressor, into the pipelines and finally into the pneumatic tools, causing trouble and expense.



COMPRESSED-AIR DUST FILTER

After considerable experimenting with various types of screens the following was adopted: A piece of 12-in. pipe, about 4 ft. long, was fitted with cast-iron screwed flanges on both ends. A cast-iron plate, tapped for a 4-in. pipe was bolted to the lower end, also four wrought-iron supporting legs.

A rough grate, made up of strips of 2x¼-in. flat iron with ¾-in. pipe separators 1½ in. long, and held together with one ½-in. bolt 11¼ in. long, was placed on the bottom. The pipe was filled to within 5 in. of the top with stones about the size of a large orange. The stones were dipped in a thick, sticky refuse oil, which

happened to be handy at the time, before they were placed in the pipe. As we figured that in time the oil would work to the bottom, a second grate, similar to the other, was placed on top of the stones so the apparatus could be turned over and used in a reversed position. A flange and gasket similar to that on the bottom was placed on the upper end. Drip cocks were also placed near each end so that any accumulated water might be removed. The line from the compressor was then connected to the bottom flange, by nipples, ells and flanged unions; the same arrangement was used on the upper end to convey the filtered air to the machines.

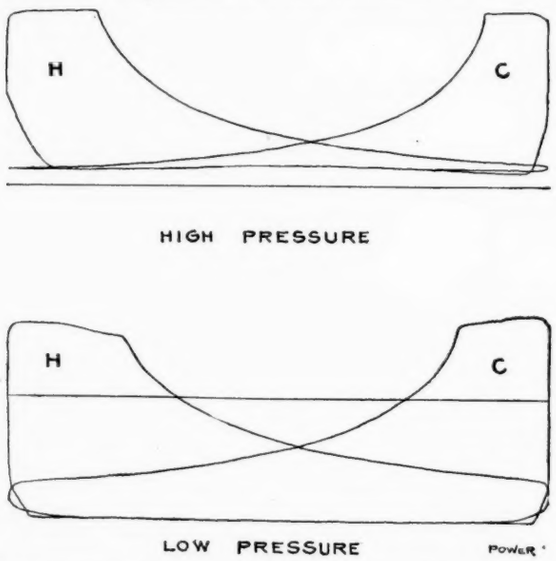
Since installing this device two years ago we have cleaned it twice, and on each occasion found that a large amount of dirt, lint, etc., had been collected by the oil, without any reduction in the efficiency of the oil. This same arrangement can be used on the discharge end of all lines if they are of any great length, as all wrought-iron pipe will shed loose scale, especially when first put in service, also after being out of use for some time.

W. G. HARRIS.

Elizabeth, N. J.

Indicator Diagrams from High Duty Pumping Engine

Yes, dear reader, you are right. The steam eccentric should be advanced a hair, the exhaust eccentric backed up three-eighths of an inch, the rod connecting the exhaust valves lengthened one full turn and the crank-end



INDICATOR DIAGRAMS FROM HIGH-DUTY PUMPING ENGINE (HIGH-PRESSURE CRANK LEADS THE LOW BY 90 DEG.)

governor rod lengthened one-sixteenth; but what causes the back pressure to increase slowly until midstroke and then slowly fall away until compression begins?

Don't spoil it all by asking if the cylinder is steam jacketed.

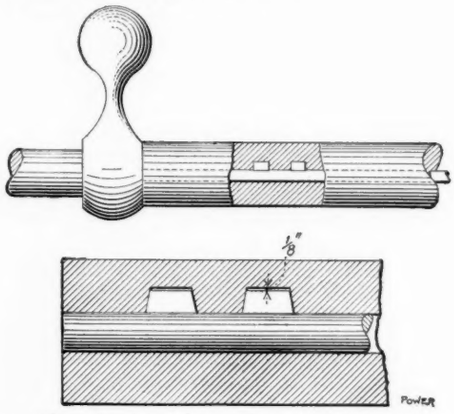
L. C. TUCKER.

Newburyport, Mass.

[Our correspondent has anticipated the common criticisms and perhaps his own question. What would interest us more, is how he got that cutoff on the crank end of the high-pressure cylinder. Looks a little like a sticky indicator.—EDITOR.]

Reach Rod Lost Motion Eliminated

At the plant of which I have charge, trouble has been experienced in keeping the lost motion out of the engine reach rods. Shims were fitted each year when repairs were made, and, although the amount of wear would be small, it caused a disagreeable noise.



REACH ROD AS IT WAS, ALSO SHOWING ALTERED SHAPE OF THE TEETH

As the slots in the reach rods are made square, the teeth which fit in them are enough smaller to allow of easy connection. While making repairs last summer, I had the teeth and recesses made on a slight taper with the teeth large enough to bind on the sides before the bottom was within 1/8 in. from striking, as shown by the sketch. This makes it easy to hook up and has entirely and permanently removed the lost motion.

E. W. MEEKER.

Cambridge, Mass.

Number of Boiler Passes

In an advertisement I noticed the claim that "the last pass of a boiler does not pull its own weight." I should like to ask the opinion of engineers on that subject. If this is true, why are some boilers being built now with four passes?

Furthermore, the statement does not coincide with the conclusion arrived at in the Bureau of Mines bulletin on the "Transmission of Heat into Steam Boilers," where the prediction is made that the boiler of the future will have more passes with proportionally smaller area of gas passages than at present on account of the increased economy to be realized. In this connection I should also like to state that I know personally where economizers were dropped from a proposed boiler house because the manufacturers were unwilling to guarantee that they would pull their weight.

CHARLES COBB, JR.

Kewanee, Ill.

[Mr. Cobb will be interested in the editorial entitled "Four Pass Boilers," in the Sept. 17 issue, and a letter discussing this editorial which appeared Feb. 25. We shall be glad to hear from any other readers having anything to offer on the subject.—EDITOR.]

Fireman "Lost His Head"

The following experience illustrates the necessity of "looking before you leap." Some years ago the writer was employed as a fireman in a plant having ten 250-hp. locomotive-type boilers, operating at 110 lb. pressure. Normally nine of the boilers were in operation and were handled by a force of three firemen, one of whom also attended to the needs of the feed pumps, which were in a room at the back of the boiler room.

One evening the chief fireman had gone to the pump room to attend to the lubricators, having first coaled his fires sufficiently to last the few minutes he expected to be away. On his return he heard the high- and low-water alarm sounding on No. 3 boiler, which was one of his set. Glancing up at the gage-glass and failing to see the water level, he immediately opened the blowoff valve a little and proceeded to coal up his fires, expecting the water soon to return to its normal level. When he finished coaling, the whistle was still sounding. The water could not yet be seen in the glass, so he then tried the gage-cocks which revealed that instead of being full of water the boiler was empty with a fierce fire in the furnace. First closing the blowoff valve, he speeded up the pump and, not content with this, he started the injectors.

About this time, while on duty at the further end of the room, I heard a violent pounding coming from the direction of No. 3 boiler. Running along the firing alley to investigate I noticed the empty gage-glass and divining the trouble, shouted to the chief to close the stop valve on top of the boiler, at the same time I closed the feed valve and, grabbing a shaking bar, dumped the fire into the ashpit.

By this time the pounding had ceased, but the whistles on all the other boilers were blowing, as a result of the increased speed of the pump and the extra water supplied to them by the injectors. An inspection of No. 3 boiler revealed a badly sprung firebox and showed that most of the tubes leaked at the ends.

Wheeling, W. Va. ROBERT TOMLINSON.

Overhauling Engine Pistons

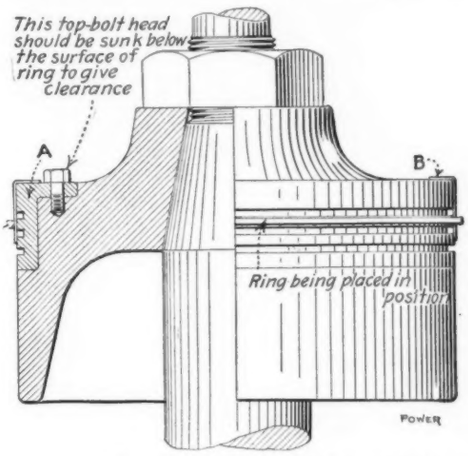
We all know of the losses incurred in steam-engine practice by leaky pistons, and, therefore, realize the necessity of frequently taking indicator diagrams to reveal these losses. It is probably good practice to overhaul the engine pistons every six months.

The designs of pistons vary from the simple solid block with grooves cut in its circumference to prevent leakage, to the types found in power stations and marine work, which have dozens of springs and segments all set together to form a continuous ring in contact with the cylinder wall. No matter what the design is, the function of the piston packing is the same in all cases, namely, to give a steam-tight working joint with a minimum of friction between the working parts.

With this end in view all springs in a spring-ring piston ought to be light, consistent with the working pressure, and with tension just sufficient to hold the surface of the ring in contact with that of the cylinder, against vibration and irregularity of the cylinder-wall surface.

One of the simplest and best pistons made, and one easy to overhaul, is shown herewith. The carrier *A* is of L-shaped section with three grooves sunk in its perimeter to hold in position three split cast-iron rings. To overhaul this type of piston, all that is necessary, once the cylinder head is removed, is to slacken back the tap bolts, which hold the carrier to the piston proper, then the carrier and rings can be lifted out and the rings examined for wear circumferentially and also as to width, for when there is too much clearance in the grooves, the rings chatter and are, therefore, more likely to become broken. If there is too much play, they should be replaced with rings of a breadth which is just a good fit, easily moved in the slot by hand. On no account should the rings be fitted tight, as they are likely to bind and be prevented from making contact with the cylinder wall.

In fitting rings circumferentially they must be fitted in the cylinder bore at its smallest diameter, after they have been split, and should be of a good fit, able to hold their own weight when in position, and about $\frac{1}{16}$ in. open at the joint where they are cut. If these conditions prevail the rings are ready to be sprung on the



PISTON WITH DETACHABLE PISTON-RING CARRIER

carrier. In doing this, care should be taken, as being of cast iron and very brittle, the rings are likely to be easily broken. Before the new rings are placed in position the carrier and grooves should be trimmed up with a smooth file and all sharp edges taken off.

The easiest and safest way of putting the rings in position is to take four pieces of sheet iron, $\frac{1}{16}$ in. thick by ½ in. wide, and long enough to reach from the top edge of the carrier to the edge of the bottom groove, as shown at *B*. They should be bent L-shaped so that they cannot slip when a ring is being passed over them. These strips enable the rings to be slipped past the other grooves and placed where they belong.

Whatever attention is given to the piston is more than repaid in reduced steam consumption of the engine and smooth running of the plant. Therefore, a systematic overhauling of the piston is desirable in any plant.

Southampton, England. C. F. MACDONALD.

The 160-mile transmission line from the Ocoee River hydro-electric development of the Tennessee Power Co. to Nashville, connecting the system of the Nashville Ry. & Light Co., will be completed early in May. Only 20 miles more of wire remains to be strung. The work on the steel towers carrying the 66,000-volt lines is being pushed and it is expected the large force employed will be able to complete the work and enable the Nashville Co. to distribute hydro-electric power within 90 days.

QUESTIONS BEFORE THE HOUSE

The Average Owner

On page 980, Dec. 31 issue of POWER, is an editorial under this title: "The Average Owner," which, according to my experience, observation and analysis of conditions among such plants and their owners does not represent them as I have always understood them.

In dealing with the average plant we are confronted not only with dense ignorance, but also with an acrimonious passivity and psychic inertia that would stagger a government mule. I know the average plant and its atmospheric tension and morbidness. This is not said with the exclusion of the average plant owner, because you know that the atmosphere or spirit of any institution, no matter whether it is a power plant or a dry-goods store, is always dominated by its head, i.e., the personality of the man at the head, or leadership of the institution. The profound tact, knowledge and resourceful arguments of the uptodate engineer will be about as effective in such a plant as the idle winds. And if persisted in is likely to cause him to be looked upon as a nuisance or a cheap sort of side show.

But the well informed engineer is never found in such a plant, because there are no attractions there for him, and because he is not wanted is the reason for lack of attractions, and the reason he is not wanted is because the owner does not know what an engineer is.

When the owner becomes sufficiently awakened by the process of time and evolution and begins to realize that there are many things about the works that he does not quite understand, which are holding down the dividends, he begins to wonder if there is someone who does understand these things, and finds the engineer the person he needs. Under that condition the engineer gets a hearing when he wants something, but an engineer who is not president of the company, or an influential member of the board of directors of the average plant will not get on very fast, and moreover, will not stay there.

Then, too, a man who is studying for engineering soon develops ability that takes him away from the average plant, to one where he gets better remuneration, a better position and has a better prospect. Very meager wages are the rule among the average power plants. Also likewise very crude inefficient workmen are employed. The employers do not manage their business as they should, and the men they employ, and the wages they pay are a direct reflection of their judgment in general. Also the factory is not properly lighted and ventilated, the machinery not placed to the best advantage, which necessitates much extra handling of material and many other things come in here, all of which detract from the profits.

They have to pay for knowledge, before they will receive it. There is no use to try to give it to them, nor even to pound it into them, because they cannot see it, and, therefore, do not want it. Time and experience are the only agents that will change the average plant owner's notions of plant operation.

The letter on the lower right-hand corner, page 982 of POWER for Dec. 31 is typical of the average owner. I know the plants and country around Platteville, but never expected to see a letter from that neck of the woods published in POWER, and the author of the letter is more promising, energetic and ambitious than is the average individual of the neighborhood in plant life. He will see his mistake in a few months, and in that respect is much in advance of the average engineer or owner.

THOMAS C. ROBINSON.

Fort Madison, Iowa.

Cause of Knock in Gas Engine

In answer to Mr. Robnett's query in the Dec. 3 issue, page 837, as to the cause of the knock in his 60-hp. gas engine, I would advise that from the description he gives the knock is caused by a weak exhaust-valve spring. The fact that the engine runs quiet when up to speed is evidence that the trouble is not caused by any slack main journal or worn piston rings. If the exhaust-valve spring is weak enough to allow the valve to open on the suction stroke when the governor at full speed throttles the charge, there will be heard a click or knock when the valve seats itself at the end of the stroke. There may be a repeated sound as if the valve slapped against the seat two or more times. At a certain load this sound will be irregular, and will cease as the load is increased. For a four-cycle engine this knock will occur every second revolution.

The trouble being in one cylinder only would indicate either that one spring is weak, or, if there is one throttle valve for each cylinder, that the governor throttles more for one cylinder than for the other. The remedy in this case would be to adjust the governor connection so as to throttle equally in all cylinders. If the exhaust-valve spring actually is weak, a washer put under the valve-stem cap may increase the tension of the spring sufficiently to stop the noise. The force required in a spring to resist the partial vacuum formed in a throttling-engine cylinder at lightest load should be from 9 to 12 lb. per sq.in. of valve area.

Mr. Robnett states that the engine knocks while coming to speed. I presume this to mean the period before the load is thrown on, and if so, the throttling of the charge would have much influence on the action of the valve. If the statement refers to the short period (a matter of a few turns probably) while the engine is actually speeding up, there would then be no throttling; except by watching the governor it would be hard to tell exactly when throttling takes place.

A. M. LEONARD.

Chicago, Ill.

Mr. Robnett does not give complete details of his engine. Likely the throttling governor is at fault, either hunting or lagging, due to being too stiff or to the link-

being adjusted too tightly. If so, the engine would act as follows:

In increasing the speed of the engine, the governor would tend to lag and the engine would not get sufficient fuel on one stroke and the mixture would fail to ignite. On the next stroke, however, the governor having dropped, owing to the reduction in speed, would insure an increase in the quantity of fuel admitted to the manifold. There would be an explosion in the cylinder and the hot exhaust gases would ignite the weak mixture in the discharge pipe, causing a pronounced thump. This same action and explanation would account for the knock in one cylinder at every other revolution of the engine, if the gas leads to the various cylinders were so arranged that, while one cylinder got the full mixture, the other did not, and would also account for the knock disappearing at half load and loads above half load.

R. H. DANFORTH.

Annapolis, Md.

Solution of Reinforced Lap Joint Problem

In the Nov. 5 issue, J. H. Armstrong asks for the efficiency of a single-riveted lap joint which has been reinforced by a cover plate on the inside of the boiler.

At first, it looks simple to determine the efficiency of this joint. Referring to Fig. 1, we see that the joint will fail apparently by the shearing of the rivets X and Y, or by the tearing of the plate along the line of the X rivets (the line EF on Fig. 2). The plate cannot tear at any other place between X and Y, for, if it did, the rivets X would have to shear first to permit such action. If the joint has been well made and the rivets each take their share of the load, rivets X would not shear before rivets Y. Hence, the plate can tear only along the line EF.

If we draw the lines AB and CD, Fig. 2, we get a strip $ABCD$ $4\frac{1}{8}$ in. wide, which we will call the unit strip. All our calculations are based on this piece, as the whole joint can be looked upon as a continuous line of these sections. The efficiency of the joint can be computed just as well from such a unit strip as from the whole length, with much more ease.

Referring to Fig. 2, we see that the strength of the unperforated strip will be equal to the product of the width of this strip, the thickness of the boiler plate and its tensile strength, or strength of the imperforated plate is

$$4\tfrac{1}{8} \times \tfrac{5}{16} \times 55{,}000 = 70{,}900 \text{ lb.}$$

The strength of the perforated plate in tension (along the line EF) equals the difference between the width of the strip and the diameter of the rivet hole multiplied by the product of the thickness of the plate and the tensile strength, or strength of the joint in tension is

$$(4\tfrac{1}{8} - \tfrac{3}{4}) \times (\tfrac{5}{16}) \times (55{,}000) = 58{,}000 \text{ lb.}$$

To find the strength of the joint in shear, we see that there are three rivets in single shear in the unit strip. The area of each rivet equals 0.442 sq.in. The force necessary to shear off one of them equals the product of the area of the rivet and the shearing strength of the rivet material, or the force to shear one rivet is

$$0.442 \times 42{,}000 = 18{,}560 \text{ lb.}$$

Hence, for the three rivets, the total force is three times as great, or 55,680 lb. So, the joint is weakest in shear and its efficiency will be the ratio of the weakest strength to the strength of the imperforated plate, or

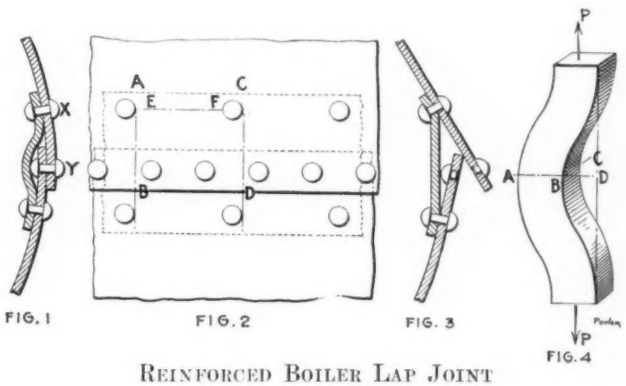
$$\textit{Efficiency} = \frac{55{,}680}{70{,}900} = 78.6 \textit{ per cent.}$$

as Mr. Armstrong calculated it.

The efficiency of the single-riveted lap joint without the cover plate can similarly be computed at 52.3 per cent., it also being weakest in shear.

Hence, we have, apparently, increased the efficiency by 40 per cent. of the original value by the addition of this cover plate. I doubt any such great increase, but would place the efficiency of the joint from 45 to 60 per cent. instead of 78.6 per cent.

The reasons for this statement are these: For the best results, the cover plate should be a snug fit against the inner heads of rivets Y. If it were not, the pressure on the cover plate would tend to straighten the latter, causing an extra strain on the Y rivets. This would be very large, as the cover plate would act like a toggle or knuckle joint. Only a very slight separation of the plate and rivet heads would be necessary to produce this effect, and it would be very hard to get a snug fit



REINFORCED BOILER LAP JOINT

along the whole length of the boiler seam. This action could be relieved partially by not calking the cover plate and allowing steam to get between this plate and the boiler plate. Otherwise, the cover plate, if it were not stiff, might be a source of weakness and the joint would be stronger without it.

But even with the cover plate snug against the rivet heads, the theoretical efficiency would not be realized. The rivets X and Y would not shear together, the rivets Y shearing first. The cover plate would probably bend straight between the rivet holes before the rivets X would give way (see Fig. 3). Of course, this would depend on the stiffness and thickness of this plate. Assuming its thickness to be equal to that of the boiler plate and, taking the approximate proportions as shown from Mr. Armstrong's drawing, I have calculated that the force acting along the circumference of the boiler plate would have to be about 1000 lb. per sq.in. to start straightening the plate. Hence, for the unit strip, the force would be

$$1000 \times 4\tfrac{1}{8} = 4120 \text{ lb.}$$

Using this value and considering that the rivets Y will shear before the others, I have calculated the efficiency of the joint to be about 60 per cent.

As for the force necessary to straighten the cover plate in this joint, I have calculated as follows:

Distance AB = thickness of the plate = $\frac{5}{16}$ in.

Distance BC = width, arbitrarily taken as 1 in.

Distance CD represents the offset to get around head of rivet = height of rivet head.

Height of head usually taken as 0.6 of rivet diameter = $\frac{15}{32}$ in. approximately in this case.

The question is what force P is necessary to start straightening the plate?

It is obvious that the plate will start to straighten when the greatest stress across the section ABC has passed the elastic limit stress for the material. This latter value may be assumed at about 32,000 lb. per sq.in. for low-carbon boiler plate. The greatest stress will occur along the inside of the bend, or along the line BC, and will be numerically equal to the sum of the stress due to the tensile load on the piece and the stress due to flexure or the fact that P is off center. This can be expressed:

$$\textit{Elastic limit stress} = \frac{P}{\textit{area } ABC} + \frac{\dfrac{\textit{bending moment on } ABC}{\textit{moment of inertia of section } ABC}}{\frac{1}{2}\textit{ thickness of plate}}$$

or,

$$32{,}000 = \frac{P}{\frac{5}{16} \times 1} + \frac{(P\,\frac{15}{32})}{\frac{\frac{1}{12}\,(1)\,(\frac{5}{16})^3}{\frac{5}{32}}}$$

solving, P = 1000 lb.

I agree with Mr. Armstrong that an applicant would be "up against it" with such a problem. The examiner must have put it in as a catch question or else through ignorance on his own part.

S. R. Wing.

Ithaca, N. Y.

Comment on Air Receiver Explosion

No matter what the occurrence may be, how seemingly impossible of explanation, or how vague the details, the word "mystery" has no place in the reports of boiler failures or compressed-air receiver explosions and its use in this connection, literally or by inference, should not be permitted to pass unquestioned.

Recently contributed reports of air-receiver explosions have been remarkably suggestive of "mystery," and they have also been noticeably deficient in presenting such facts and data as would permit the necessary calculation to ascertain the safe working strength of the receivers, if the reader so desired.

When one reads the account of an air-receiver explosion which states that "the receiver was being operated under normal conditions when suddenly the bottom of the receiver was observed to be red hot, closely followed by the explosion," and that "subsequent investigation showed that an accumulation of oil and grease on the interior surface had ignited, presumably from the heat of compression, the ensuing combustion so weakening the sheets that the failure resulted," the sensations produced, if he labors where a receiver operated under like conditions is installed, are much like those of the man who was told that the can he had been carelessly throwing around was full of nitroglycerin.

Occasionally, a report will include the data necessary for calculating the safe working strength of the exploded receiver and the reader is privileged to consider this factor and its possible bearing on the cause of the explosion. The report of the explosion of an air receiver at the McNamara silver mine, Tonopah, Nev., which appeared on page 810, in the Nov. 26 issue, which states that the "apparent" cause of the failure was the "ignition of oil and grease in the receiver," and which also contains the necessary data for calculation, is an instance where fact tends to controvert theory.

The shell of this receiver is described as 4 ft. in diameter and 16 ft. long, the longitudinal seam being a single-riveted lap-joint. The thickness of the plate is given as $\frac{3}{8}$ in. Assuming the tensile strength to be 45,000 lb. per sq.in., and the per cent. of strength of the longitudinal joint as 0.56, the bursting pressure of the receiver is computed from the formula:

$$\frac{\textit{Tensile strength} \times \textit{thickness of plate} \times \textit{efficiency of joint}}{\textit{radius in inches}}$$

Substituting values,

$$\frac{45{,}000 \times 0.375 \times 0.56}{24} = 393.7 \textit{ lb. per sq.in.}$$

As 5 is the usual factor of safety for this type of construction, the safe working pressure will be $\frac{1}{5}$ the bursting pressure, or

$$393.7 \div 5 = 78.74 \textit{ lb. per sq.in.}$$

The pressure carried was stated in the report to be 100 lb. (gage). As this is nearly 25 per cent. greater than the commonly accepted rules of safety would sanction, and as it is reasonable to suppose that the receiver had become more or less weakened from corrosion during its seven and one-half years of service, there seems to be good grounds for doubting the "oil ignition" theory in this instance at least.

It must be admitted that the elements which enter into the compression of air are such as to be capable, under certain conditions, of being ignited and exploding, but I am very skeptical that the required conditions are ever present in the ordinary process of compressing. For twenty years I have observed air compressors and receivers subjected to abuse, if introducing unfit lubricants into the compressor and receiver can rightly be termed abuse. In locomotive practice I have seen enginemen admit quantities of kerosene, lard oil, tallow, car oil, engine oil and cylinder oil through the suction inlet of the air pump in their efforts to stop the annoying "groaning" of the pump, and, although the drainage of these receivers almost without exception shows the presence of oil, I fail to recall an instance of receiver failure.

Like the "hidden lap-seam crack" in boiler explosions, this "oil-ignition" theory makes a good "cover" for the concealment of gross carelessness in operating equipment which was unsuited for the purpose for which it was used, and unless more conclusive evidence than has yet been presented is forthcoming it is likely to be so regarded.

Lynn, Mass. Joseph King.

As a result of a dinner given by the Minneapolis General Electric Co., the Minneapolis Electrical Board, consisting of seven members, has been formed. Each member represents one of the following electrical interests: Wholesale houses, retail dealers, sign manufacturers, contractors, fixture dealers, city inspection department, and the central station. The board will meet once each month for the discussion of things of mutual interest, and every effort exerted toward the greater electrical development of Minneapolis.

INQUIRIES OF GENERAL INTEREST

Gravity—What is meant by the force of gravity?

K. V. S.

All matter on or near the earth is attracted toward the center of the earth by a force known as gravity. The weight of any given body is the effect of this attraction.

Nonfreezing Mixture for Gage Pipe—Where a steam gage must be exposed to a low temperature, what is a suitable mixture with which to fill the gage and pipe leading to it so that it will not freeze?

J. C.

Numerous nonfreezing mixtures are suitable, but a cheap and effective fluid is plain kerosene oil.

Pipe-Covering Tests—Where may one obtain reports or data of tests on the efficiency of pipe covering and the heat loss to the atmosphere per unit of exposed surface?

J. G. B.

A compilation of tests on the heat lost through various pipe coverings is given in Paulding's "Condensation of Steam in Covered and Bare Pipes." The table is reprinted in the Stirling Boiler company's catalog, page 219.

Kerosene a Distillate—How much solid matter is there in a barrel of kerosene, i.e., how much residue would remain after evaporating 50 gal. of the oil?

J. H. T.

There should be no solid matter in kerosene unless it got into the oil subsequent to the manufacture, for kerosene is obtained by distilling heavier oils and, being a product of recondensation, will vaporize entirely if pure.

Motor-Generator Efficiency—What is the usual efficiency of a motor-generator set?

C. Y. L.

The efficiency of a motor-generator set depends upon its size. If both sides are direct-current, it will vary from about 72 per cent. for one of 5 hp. to about 82 per cent. for one of 100 hp. If either or both sides are alternating current, the efficiency will be further reduced by the power factor.

Variation of Atmospheric Pressure with Altitude—Why does the atmospheric pressure decrease as the altitude increases?

V. K. S.

The pressure of the atmosphere at any point is due to the weight of air above that point. At any greater elevation the amount and hence the weight of air still above being less, the pressure will also be less.

Restoring Polished Surfaces—How can the polished surfaces of an engine be made bright again after becoming coated with burned or baked oil and dirt?

J. F. C.

The discoloration generally is not very deep and then can be removed with emery cloth. If oil and dirt have become baked on as a thick coating, oxalic acid will soften it, but the bright surfaces can be restored only by scraping and polishing with emery cloth.

Specific Gravity of a Body—What is the specific gravity of a body and how is it found?

S. K. V.

The specific gravity of a body is its weight for a given volume as compared with the weight of an equal volume of water. To find the latter, weigh the body in the air and then immersed in water. The difference between the two weights will be the weight of water displaced or the weight of the equal volume of water. Dividing the weight of the body in the air by the weight of the displaced water gives its specific gravity.

Pressure of Water Head—If a gage is attached at the foot of a 1-in. vertical pipe filled with water to a height of 34 ft., what should it register?

J. M. H.

The size of the pipe has no bearing in the matter, for the pressure due to a column of water is independent of the area of its cross-section, depending only on its height, and the density of the water, which varies with its composition and temperature. If the surface of the water stands 34 ft. above the center of the gage, the water is fresh and the temperature is about 62 deg. F., each foot of height will create a pressure of 0.433 lb. per sq.in., and a correct gage should indicate

$$34 \times 0.433 = 14.722 \text{ lb. per sq.in.}$$

Polarity of a Dynamo—How can one determine which are the north and which the south poles of a dynamo?

G. K.

This cannot be determined by mere inspection unless it is known in which direction the current flows around each pole. This being known, the north pole will be found at the end toward which the core would travel if it were a right-hand screw and were revolved in the direction that the current travels. The polarity can be determined by a test with a permanent bar magnet or with a magnetic compass. If the north end of such a magnet is attracted when brought toward a pole face it indicates that that face is a south pole; if repelled, that it is a north pole. The magnet, especially if a compass, must not be brought so close that the greater force of the machine pole may reverse its magnetism, for then it would be attracted regardless of its original magnetic condition.

Exhaust-Steam Injector—How can exhaust steam from a noncondensing engine force water against boiler pressure as is done in the exhaust-steam injector?

H. H. J.

It is not by the direct pressure of the steam that any injector forces water into a boiler. In the injector the steam is condensed and, its volume being greatly reduced, its pressure would be also, no matter how high it had been originally. The principle is different; the steam passing through an expanding nozzle has its energy converted into velocity, and, being injected into the core of a contracting column of water, is condensed, and water closes in behind to fill the vacuum. Meantime velocity has been imparted to the combined column of water and condensed steam and, proceeding through the expanding delivery tube, the velocity is largely converted back to pressure.

In a sense an injector may be compared to a lever or any force-multiplying mechanism. Where the pressure of the steam is low (as in an exhaust steam injector) it simply means that more steam must be used relative to the quantity of water delivered against the given pressure. The analogy with a lever is that where the working force is small the lever must be longer to lift a given weight.

Saving by Covering Boiler—A boiler has 2000 sq.ft. of surface exposed to the atmosphere in a boiler room whose average temperature is 100 deg. F. The steam pressure is 110 lb. gage. Crude oil is burned of a calorific value of 18,700 B.t.u. per lb., costing $1.20 a barrel of 315 lb. In an operating period of 4000 hr., what would be the saving by putting on the exposed boiler surface a covering of 85 per cent. efficiency?

B. G. J.

The temperature of steam at 110 lb. gage is 344.2 deg. F. The difference of temperature between the steam and the boiler room is, therefore,

$$344.2 - 100 = 244.2 \text{ deg. F.}$$

At the usual assumption of 3 B.t.u. radiated per hour per square foot per degree difference of temperature, the total loss in 4000 hr. is

$$3 \times 4000 \times 2000 \times 244.2 = 5{,}860{,}800{,}000 \text{ B.t.u.}$$

The calorific value of the oil being 18,700 B.t.u. per lb., and the evaporating efficiency of the boiler probably 75 per cent., the heat put into the steam by each pound of oil is about

$$18{,}700 \times 0.75 = 14{,}025 \text{ B.t.u.}$$

and by each barrel,

$$14{,}025 \times 315 = 4{,}417{,}875 \text{ B.t.u.}$$

To cover the loss then will require

$$\frac{5{,}860{,}800{,}000}{4{,}417{,}875} = 1327 \text{ bbl. of oil,}$$

costing

$$1327 \times 1.20 = \$1592.40.$$

Covering of 85 per cent. efficiency would, therefore, save

$$\$1592.40 \times 0.85 = \$1353.54.$$

ENGINEERS' STUDY COURSE

Mensuration—Part V

Pyramid, Cone and Frustum

A *pyramid*, Fig. 1, is a solid, the base of which is a polygon and the sides triangles. The point where the lines forming the sides meet is called the *apex* or *vertex* of the pyramid.

The perpendicular distance between the apex and the base, as indicated by the dotted line, Fig. 1, is termed the *altitude* of the pyramid.

The *slant height* of a side of a pyramid is the altitude of the triangle forming that side.

The *lateral edges* of a pyramid are the lines from the apex to the corners of the base.

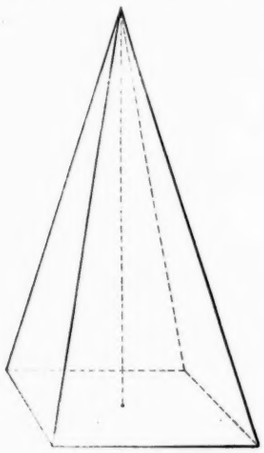


Fig. 1

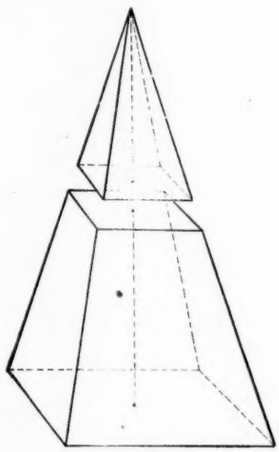


Fig. 2

If we cut off the top of a pyramid, as in Fig. 2, the lower or remaining part will be a frustum.*

Cones

A circular cone is a solid whose base is a circle and whose sides taper uniformly to a point called the apex or vertex. Fig. 3 shows a circular cone. The altitude of a cone is the perpendicular distance between the apex and the base, as shown by the dotted line, Fig. 3.

The *slant height* of a cone is the distance between the apex and a point on the circumference of the base.

A frustum of a cone is formed in the same way as the frustum of a pyramid, as shown in Fig. 4.

The altitude of a frustum of a pyramid or cone is the perpendicular distance between the upper and lower bases, as shown in Figs. 2 and 4.

The slant height of a frustum is the perpendicular distance between the corresponding edges of the upper and lower bases.

Areas

You have undoubtedly noticed that the sides of a pyramid are made up of triangles of which the altitudes are equal to the slant height of the pyramid, and whose bases are equal to the edges of the base of the pyramid, which if a regular polygon will produce equal bases for all the triangular sides. We may also consider a cone as a pyramid of which the base is a regular polygon with a great number of sides, for we know that if we make a polygon with a sufficient number of sides we will produce a nearly perfect circle.

We may now make the following rules for the areas of the pyramid and cone and their frustums:

Rule: *To find the lateral area of a pyramid or cone, multiply the perimeter of the base by one-half the slant height.*

The overall or total area equals the lateral area plus the area of the base.

Rule: *To find the lateral area of a frustum of a pyramid or cone, multiply one-half the sum of the perimeters of the upper and lower bases by the slant height.*

Example: The roof of a tower shaped like a pyramid and of the following dimensions, one side of the base 42 ft., and the slant height 62 ft., is to be covered with sheet copper. Allowing 60 sq.ft. extra for the seams and waste, how many square feet of copper will be required?

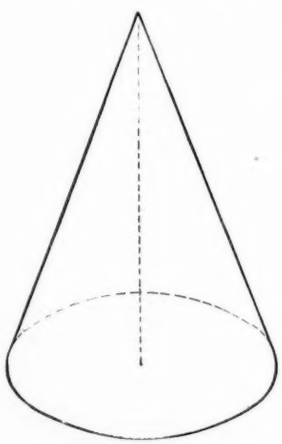


Fig. 3

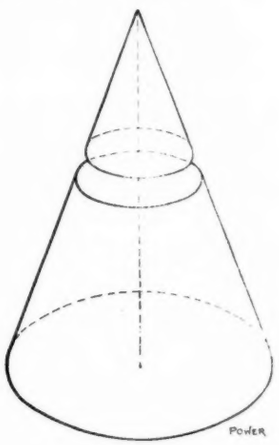


Fig. 4

The perimeter of the base will be

$$42 \times 4 = 168 \; ft.$$

and the lateral area will be

$$168 \times \tfrac{62}{2} = 5208 \; sq.ft.$$

The copper necessary will be

$$5208 + 60 = 5268 \; sq.ft. \quad \text{Ans.}$$

Example: How many square feet of copper would have been necessary if the tower in the above example had been shaped as a cone of which the base was of the same diameter and the slant height was the same.

The perimeter or circumference of the base would be

$$3.1416 \times 42 = 131.94 \; ft.$$

and the lateral area would be

$$131.94 \times \tfrac{62}{2} = 4090.14 \; sq.ft.$$

*Some authorities say that the upper and lower bases need not be parallel, but for the purposes of this course it is preferred to consider that one of the conditions of a frustum.

Allowing 60 sq.ft. for the seams and for waste, the amount of copper necessary will be

$$4090.14 + 60 = 4150.14 \textit{ sq.ft.} \quad \text{Ans.}$$

The 12x12x24-in. prism, Fig. 5, has six sides, and examination of it will show that it contains six pyramids, the four sides of the prism forming the bases of four pyramids, and the two ends of the prism making the bases of the other two pyramids. For convenience the bases of four pyramids only have been numbered, 1, 2, 3 and 4.

This prism has a certain volume and as it contains six pyramids their total volume will equal the volume of the prism.

The rule for finding the volume of a pyramid or cone is:

Rule: *The volume of a right pyramid or cone equals*

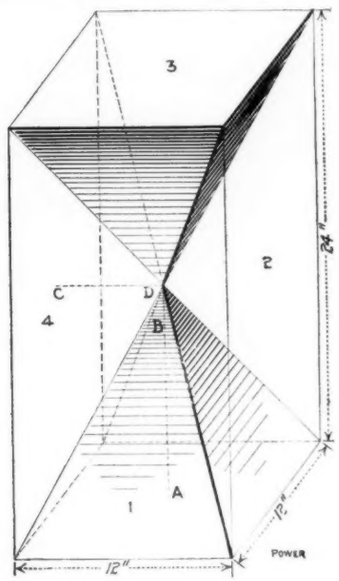


FIG. 5

the area of the base multiplied by one-third the height or altitude.

Then the volume of either the upper (inverted) or lower pyramid in Fig. 5 will be

$$12^2 \times \tfrac{1}{3}^2 = 576 \textit{ cu.in.}$$

Let us apply the rule to one of the pyramids with the large or 24x12-in. bases. The altitude *CD* is one-half the width of the prism, or 6 in., so the volume will be

$$24 \times 12 \times \tfrac{6}{3} = 576 \textit{ cu.in.}$$

We see that the volume of each pyramid in the prism is equal to one-sixth of the volume of the prism and so must equal the area of the base times one-third the altitude *BA* for the end pyramids and one-third of *CD* for a pyramid the base of which is the side of the prism.

The volume of a cone is also equal to one-third the volume of a cylinder with a like base and altitude, just as the volume of a pyramid is one-third the volume of a prism of an equal base and altitude. This explains the rule for the volume of a pyramid or cone.

When coal, crushed stone, sand and other fine material is dumped on the ground or surface through an opening considerably above the surface, the pile will assume the form of a cone.

Example: A long ton (2240 lb.) of pea coal occupies 36.7 cu.ft. How many tons in a conical pile 30 ft. in diameter with an altitude of 43 ft.?

The volume of the pile is

$$30^2 \times 0.7854 \times \tfrac{43}{3} = 10{,}131.66 \textit{ cu.ft.}$$

So its weight in tons must be

$$10{,}131.66 \div 36.7 = 276.07 \textit{ tons}$$

To find the volume of a frustum of a pyramid or cone:

Rule: *Add together the areas of both bases, the square root of the product of both bases and multiply the sum by one-third of the altitude.*

This rule is more conveniently expressed as a formula.

$$V = \tfrac{1}{3} h \,(B + b + \sqrt{B \times b})$$

in which

V = Volume;
h = Height or altitude;
B = Area of lower base;
b = Area of upper base.

Example: Medium-hard brickwork will weigh 125 lb. per cu.ft. What will be the weight of a brick-engine foundation shaped as a frustum of a pyramid, the lower base of which is 12x8 ft.; upper base, 10x6 ft. and having an altitude of 9 ft.?

Substituting these values in the formula we have

$$V = \tfrac{9}{3} (12 \times 8 + 10 \times 6 + \sqrt{12 \times 8 \times 10 \times 6})$$

or

$$V = 3 \times (96 + 60 + \sqrt{96 \times 60}) = 695.67 \textit{ cu.ft.}$$

The weight will be

$$695.67 \times 125 = 86{,}958.75 \textit{ lb.}$$

Example: A reservoir shaped like the frustum of a cone has an upper base 300 ft. in diameter and a lower base 260 ft. in diameter; the depth of water when full to overflowing is 21 ft. How many gallons of water could the reservoir contain?

The volume of the reservoir is

$$\tfrac{21}{3} \times [(300^2 \times 0.7854) + (260^2 \times 0.7854) + \sqrt{(300^2 \times 0.7854) \times (260^2 \times 0.7854)}]$$

or

$$7 \times (70{,}686 + 53{,}093.04 + \sqrt{70{,}686 \times 53{,}093.04}) = 1{,}295{,}281.68 \textit{ cu.ft.}$$

The capacity in gallons will be

$$\frac{1{,}295{,}281.68 \times 1728}{231} = 9{,}689{,}379.84 \textit{ gal.}$$

EXAMPLES FOR PRACTICE

(1) Cast iron weighs 0.26 lb. per cu.in. What will be the weight of a pyramidal casting (iron) whose base is 2x2 ft. and whose altitude is 18 in.?

(2) (a) A roof tank on a sprinkler system is shaped like a frustum of a cone. The lower base is 6 ft. in diameter, upper base 4 ft. 6 in. in diameter and the altitude is 8 ft.; what is its capacity in gallons?

(b) If the tank weighs 1057 lb. when empty and the allowable weight on the roof is 550 lb. per sq.ft., what will be the length of a side of the square formed by the supports of the tank?

(3) If a wagon has a capacity of 5 cu.yd. of ashes, how many wagon loads will be contained in a hopper which consists of a room 10x10 ft. wide, 10 ft. high; the floor of the room is shaped like an inverted pyramid whose altitude is 6 ft. from the lowest level of the side walls?

(4) How many linear feet of 12-in. boards are required to build a housing for a tank; the housing is to be shaped like a frustum of a pyramid whose lower base is 12 ft. square, upper base 10 ft. square and whose altitude is 11 ft.

ANSWERS TO LAST WEEK'S PROBLEMS

(1) 57.6 seconds.
(2) 61.949 sq.in.
(3) 2705.29 lb.

❖

New Blades for "Lusitania's" Turbines

The Cunard liner "Lusitania" is now at Clydebank undergoing extensive repairs to her turbines. As the blades of all her turbines, with the exception of the high-pressure port machines, are to be renewed, the Cunard authorities state that the liner will not go into service for many months.

As previously stated in POWER, the "Lusitania" has been most unfortunate with her turbines ever since her initial voyage in September, 1907. For the first few years serious trouble occurred at rather long intervals, but more recently the turbines began to show, by serious breakdowns about every three months, the effect of inadequate care, which is perhaps entirely due to the exigencies of the service and not to incompetent handling or poor design.

Some marine engineers claim that much of the "Lusitania's" turbine trouble is due to the serious foaming and priming of her triple-furnace Scotch boilers, which allow such quantities of water to get into the turbines as to seriously erode the blades, many of which have been renewed at frequent intervals lately.

According to a report in the *New York Times*, Feb. 25, which the New York office of the Cunard company will not confirm, a commission of engineers recommended that the liner be put in drydock and the blading of all her turbines, except the high-pressure port machine, be renewed, the new blades to be cast in sections and riveted to the shaft instead of fastening them singly as has been the practice. This plan was adopted because it has proved so satisfactory with the "Mauretania's" turbines. The estimated cost of the repairs is $500,000.

❖

Electrical-engineering students in the technical schools of this country in 1912 numbered 8921, according to a compilation of statistics in the "Electrical World," Nov. 23, 1912. In that year 1496 graduated, bringing the total number of graduates during the past six years up to 18,318. The statistics for the six years past are shown below.

	1907	1908	1909	1910	1911	1912
Number of students	8929	9651	8670	9041	9515	8921
Number of graduates	1358	1501	1473	1545	1614	1496

❖

It took a pull of 364 tons to break the largest hoisting cable in the world, when sections were tested early in December in the 800,000 lb. testing machine of the Fritz Engineering Laboratory at Lehigh University, South Bethlehem, Penn. Three tests were made, all highly satisfactory. A piece of the cable that had been in use for a year and a half withstood a pull of nearly 300 tons. The construction of this cable is said to be without precedent in rope-making. It consists of six strands, each of nineteen wires, twisted around an independent wire rope center, this center having six strands of nineteen wires each, twisted around a hemp core. The finished cable is 7810 ft. long, and weighs 125,360 lb. Cars with a capacity of 100,000 lb. of ore are lowered by means of this cable down an inclined plane 5800 ft. long.

OVER THE SPILLWAY

JUST JESTS, JABS, JOSHES AND JUMBLES

The first issue of Brother Mackintosh's handsome publication, "Steam Machinery," comes with a creed of "Labor with Laughter." Mac says "the times are ripe for a frivolous magazine with serious purpose"—and he only wants "one perfectly good ingodwetrust dollar for a full year's treatment." Go to it, brother! Your first essay already proves you deserve the golden wrest from the guild of ye joyous troubadours; you're some hummer!

❖

Somebody says that all the professions have benefited by mechanical invention save the lawyers. They have only the friction brake, and successfully apply it to the wheels of justice. Officer, eject Somebody from the courtroom, put a detective on Friction's trail, and call the next case.

❖

A Newport News boilermaker, "near death with appendicitis," hot-footed it for home when it came time for the hospital surgeon to "start up." The ill doctor makes the most scared patient. Here's a man who can cut out a boiler, but when the surgical "boilermaker" shows up with his little tube-scraper—awk, it can't be done!

❖

In Bulgarian currency, 100 stotinks equals 1 lev, or 19.3 cents. Just think of having to save up a hundred stotinks before you can accumulate a lev, or of putting a stotink on the plate Sunday morning. Now, Bulgaria intends to mint other coins. Bet you 2 kopecks against 1¼ yards of Chinese coin that you can't name the new issues.

❖

A mining engineer is sometimes hard put to keep cheerful under adverse conditions. One in the Golden West says he is working on the "graveyard" shift at the Dead Man mine, in the Funeral Mountains, near Death Valley. Some "embalming fluid," about 98 per cent. proof, might help, but two weeks on this job would make an ordinary man look like a professional pallbearer, and Chopin's "Funeral March" would sound like a ragtime ditty.

❖

Postals naming ten famous engineers have been received from W. C. Collins, Everett, Mass., and O. L. Sherman, Duluth, Minn. Their lists accord well with that of Prof. Kent in the Mar. 4 issue.

❖

THANKS! SAID HE

By Billy Spills

Once upon a Time there was a Molder of Public Opinion (M O P O = Editor, sometimes) whose hard Lot it was to fill the boots of old Doc. Knowitall—he had to answer the "Inquiries."

F'rinstance, when Subscriber got keen for a new License, he would corral a copy of 69 old Questions and Demand real sassy that Doc. answer them Immediate, or he'd stop Subscribing; he wouldn't even Borrow his fireman's paper. In a Manner of speaking, Doc's inquisitors Hogtied him to the Rack, and then racked him for the whole Hog.

The Pace began to tell, and Doc. looked Off his feed, bilious-like, and depressed.

One day it appeared as if the crisis had Came when Doc. ambled over to Us, determined-like. "Say, Spills," says He, "even s'posin' an editor does get Seven thousand dollars a year"—which is a Wild supposition—"the Grind thumps your nerves awful Fierce. I ain't gettin' anything but Money for all this dinged worry. If Somethin' don't happen before the End of the week, I'm agoin' to Chuck up. Do you get me, Billy?"

Something Did happen, and You wouldn't know Doc. today. He got these Few cheering lines in his Monday mail:

"I thank you for your prompt and helpful reply to my recent inquiry. * * * I am much gratified at your very satisfactory answer to my cry for help.

"GRATEFUL SUBSCRIBER."

There's nothing really True in this story except Grateful Subscriber's letter, unless you want to include Doc's Surprise.

Accuracy and Limitations of Coal Analysis

SYNOPSIS—Accuracy depends largely on the kinds of coal, methods employed and the skill of the analyst. Some interesting data to show the limits of accuracy in sampling, in obtaining proximate and ultimate analyses and heat value of coal by calorimeter or computation.

In coal analysis, discrepancies, which are more likely to occur in some determinations like that of volatile matter or of fixed carbon, tend to discredit the whole analysis in the eyes of engineers not familiar with the difficulties peculiar to such individual determination. A. C. Fieldner, of the Bureau of Mines, in a paper read before the American Coal Mining Institute, called attention to this fact. He pointed out that some constituents may be determined much more accurately than others, and presented experimental data bearing on the probable variations that may occur in good laboratory practice. In the following, only a summary of these data will be given.

Moisture

In the Bureau of Mines method, the moisture is determined in two stages: (1) the coarse sample received by the laboratory is pulverized to ¼ in. size and then air-dried at 86 to 95 deg. F. The loss in weight, which is called the air-drying loss, includes all the superficial moisture and a large portion of the loosely retained moisture. (2) The air-dried sample is then pulverized in a closed ball mill to avoid loss of moisture, mixed and sampled down to a small, powdered sample in which the residual moisture is determined, by heating one gram for one hour at 221 deg. F., in an oven through which dry air is being circulated. By this method duplicate results in the same powdered sample seldom vary more than 0.15 per cent.

Ash

The determination of ash, although one of the simplest operations, is also beset with certain difficulties that lead to disagreement among different laboratories, more especially with coals containing notable quantities of calcium carbonate and iron pyrites. For example, in certain experiments with Illinois coal that contained notable quantities of calcium carbonate and sulphur, 14 per cent. ash was obtained by ignition to constant weight at a low-red heat, and 13 per cent. ash was obtained by ignition at a bright-red heat. To secure concordant results, a standard temperature should be adopted. If this is done, duplicate determinations on the same powdered sample will agree to within 0.2 per cent.

Coal ash as determined usually weighs less than the mineral matter from which it is produced. Several methods have been proposed to compute the weight of original mineral matter in the coal, by adding corrections to the weight of ash obtained by ignition. These methods are, however, too complicated and uncertain in their general application to all classes of coal to be used in technical work.

Volatile Matter and Fixed Carbon

The volatile matter and fixed carbon represent the relative proportions of gaseous and solid combustible matter that may be obtained from the coal by heating it in a closed vessel. This is done by heating a finely powdered sample in a small, covered platinum crucible, in the flame of a Bunsen or Meker burner for exactly seven minutes. The volatile matter consists mainly of the combustible gases—hydrogen, carbon monoxide, methane and other hydrocarbons—and some noncombustible gases, as carbon dioxide and water vapor. The volatile matter does not include water present in the coal as moisture at 221 deg. F.

The residue of coke left in the crucible after deducting the ash is reported as "fixed carbon." The fixed carbon does not represent the total carbon in the coal, as a portion of this element is driven out in combination with hydrogen in the volatile matter; furthermore, fixed carbon is not pure carbon, but still contains several tenths per cent. each of carbon, hydrogen and oxygen; from 0.4 to 1 per cent. nitrogen; and about half the sulphur that was in the coal. It should be clearly understood that the terms "volatile matter" or "volatile combustible matter" and "fixed carbon" do not represent any definite compounds which existed in the coal before heating. The method of determination is purely arbitrary, and variations in temperature and rate of heating will cause variations amounting to several per cent. Even with a strict adherence to the method recommended by the American Chemical Society, variations of 3 and 4 per cent., in both the volatile matter and fixed carbon, may occur in different laboratories. One of the most prominent factors in causing variations is the temperature at which the crucible is heated. This is especially pronounced in anthracite and semibituminous coal. It is easily possible for one laboratory to report 4 per cent. and another 7 per cent. volatile matter on the same sample of anthracite, or 14 per cent. and 17 per cent., respectively, on the same sample of Pocahontas coal. The different percentages of volatile matter were actually produced by different conditions of heat treatment. Caution must, therefore, be observed in making comparisons of the volatile matter and fixed carbon in proximate analyses made in different laboratories. Even determinations made at the same laboratory by the same analyst may vary to the extent of 0.5 per cent.

Sulphur

Sulphur determinations by the "Escha" method on the same powdered sample will usually agree to within 0.05 per cent. Where much sulphur is present in visible form, as pyrite, difficulty is experienced in obtaining a representative powdered sample from the coarse sample, and somewhat greater errors due to inaccuracy in sampling may occur.

Ultimate Analysis

In an ultimate analysis, the organic matter of the coal is resolved into the chemical elements, viz.: carbon, hydrogen, oxygen and nitrogen. These elements, together with the ash, are taken as equal to 100 per cent. As there is no direct method for the determination of oxygen, it is estimated by subtracting the sum of the other five constituents from 100. This method throws the summation of all the errors incurred in the other determinations upon the oxygen.

The determination of carbon, hydrogen and nitrogen, while requiring experience and a considerable degree of analytical skill on the part of the chemist, is not subject to the arbitrary conditions that must be maintained in the proximate analysis. As the chemist is dealing with definite chemical elements, he should be able to duplicate his determinations within the following limits: Carbon 0.3 per cent., hydrogen 0.05 per cent., nitrogen 0.03 per cent.

In the present method of estimation, the oxygen percentage is subject to an error equal to the algebraic sum of the individual errors incurred in the determination of carbon, hydrogen, nitrogen, sulphur and ash. The most serious of these errors is due to the difference in weight between the ash and the mineral matter (exclusive of sulphur which is separately determined) as it occurs in the coal.

Calorific Value

The term "available hydrogen" often used in the computation of the calorific value of a coal from the ultimate analysis, is based on the assumption that all the oxygen in the coal is combined with hydrogen in the proper ratio to form water. The amount of hydrogen thus combined and not available for producing heat is equal to one-eighth of the oxygen; the remainder of the hydrogen, or "available hydrogen," is combined with the carbon and contributes to the heat value of the coal. This hypothesis is fairly well supported in the case of anthracite and bituminous coal by the general agreement of calorific values calculated from the ultimate analysis by Dulong's formula with the values determined by the bomb calorimeter.

The most accurate method of determining the total heat value is by combustion in a bomb calorimeter. The instrument should be carefully standardized by burning substances of known calorific value, such as the standard samples of cane sugar, methylene and benzoic acid that are now being furnished by the Bureau of Standards. The standardization should be conducted under exactly the same condition, and with the same thermometer that is used in the tests. The use of calibrated thermometers is essential. In carefully conducted calorimetric work, the probable error should not exceed 0.5 per cent., which corresponds to about 50 B.t.u. in the high-grade coal. This is a higher degree of accuracy than can be obtained in the usual methods of sampling, which oftentimes increase the error to 100 B.t.u.

Calculation of Calorific Value by Dulong's Formula

Before the bomb calorimeter came into general use, the heat value of a coal was frequently calculated from the ultimate analysis by Dulong's formula:

$$\textit{Calorific value in B.t.u. per lb.} = 14{,}544\ C + 62{,}028\ (H - O/8) + 4050\ S$$

In the above formula, C, H, O and S are the respective proportions of carbon, hydrogen, oxygen and sulphur.

Aside from the fact that an ultimate analysis is more expensive and time consuming than a calorimetric determination, there are the following theoretical objections to be considered:

1. The heat value of the elements—carbon, hydrogen and sulphur, as given in the formula—has not been established with any great degree of accuracy.
2. The heat value of an element in the free state and as a component of a chemical compound is not necessarily the same, as a matter of fact, it usually varies, due to absorption or evolution of heat in forming the compound.
3. The usual assumption that from the standpoint of heat development all the oxygen is combined with hydrogen, may not be true; some of the oxygen may be linked with carbon.
4. The relative accuracy of the calculated results is subject to the uncertainty of the oxygen estimation.

On the other hand, in spite of the objections just cited, there is fairly close agreement between the calorific values calculated by Dulong's formula and those determined by the calorimeter. Lord and Somermeier, in an extended series of analyses of the coals of Ohio, found that, with very few exceptions, the results obtained by Dulong's formula were within 1 to 1½ per cent. of the values obtained with the bomb calorimeter. This degree of accuracy has also been found to hold true with anthracite, semibituminous and bituminous coals from various parts of the United States.

A total of 176 analyses was selected at random from the records of the chemical laboratory so as to secure about 20 to 30 samples of each representative class of coal from the most recent lignites, through the range of subbituminous, bituminous, semibituminous and anthracite coals of Pennsylvania. For comparison a number of peats were also included in an extended table presented with the paper.

The tabulation brings out in a striking manner the variation in the relation between the heat value calculated by Dulong's formula and the true heat value as determined in the bomb calorimeter. This relation is within certain limits, characteristic of the class of coal. For instance, in coals low in volatile matter and oxygen, like anthracite and Pocahontas coal, the calculated value is usually from 0.3 to 1.5 per cent. greater than the determined value. In only very few instances is the calculated less than the determined value; in the bituminous coals, the calculated values vary both above and below the determined values usually within limits of 1.5 per cent.; in sub-bituminous and lignitic coals the calculated value becomes less than the determined value as the oxygen increases; the deviation often reaching 4 and 5 per cent.; in peat the calculated results are quite unreliable, the results being from 3 to 11 per cent. low.

Calculation of Calorific Value from the Proximate Analysis

The calculation of calorific values by formulas depending on the proximate analysis is apt to give quite erroneous results. Such methods are subject to the considerable uncertainty of the fixed carbon and volatile matter determinations. Furthermore, the variable proportion of inert volatile matter, which does not contribute to the heat value, is not taken into consideration.

A fairly accurate method of calculating the heat value of Appalachian, bituminous and semibituminous coal from the same mine and seam, is based on the constancy in heat value of the "combustible" or coal substance free of moisture and ash. The calorific value of a coal may be referred to a moisture-and-ash-free basis by dividing the

calorific value as determined by one minus the sum of the moisture and ash in the unit weight of fuel.

$$\textit{Moisture-and-ash-free calorific value} = \frac{\textit{Calorific value as determined}}{\frac{1-(\textit{per cent. moisture}+\textit{per cent. ash})}{100}}$$

Some moisture-and-ash-free calorific values of mine samples taken by engineers of the bureau at different points in a number of mines in Pennsylvania were given in tabular form, and in the same table some data on the variation in moisture-and-ash-free calorific values in car samples of coal were included. The greatest deviation in calorific value of any one individual sample from the average of the mine is usually less than 1 per cent. In only two cases in the table did it reach the maximum figure of 1.1 per cent. Obviously the calorific value of samples representing various shipments of coal from the same mine and seam can be calculated with an accuracy of about 1 per cent. by multiplying the average moisture-and-ash-free calorific value of the coal by 1 minus the sum of the moisture and ash of the various individual samples. This method of calculating will not apply to weathered coals which, on account of absorption, have lost some of their original heat value, or to coals that vary considerably in the character and amount of ash and sulphur. In the coals cited in the table the ash is usually less than 12 per cent. and the sulphur less than 2 per cent. Where the sulphur content is larger and more variable, as found in some of the coals of Ohio and Illinois, a further correction for the influence of sulphur should be applied.

Sampling

The chemist makes his analysis on a few ounces of powdered coal. If the analysis is to be of any value, this small sample must have a composition that is an average of the entire lot of coal whose value is to be established. The accuracy of sampling the commercial sizes of coal is limited to the amount and size of the largest lumps of impurities and the quantity of original sample that can be taken without incurring too great a cost. The accuracy of any method of sampling should be frequently tested by taking two or more independent samples, which are reduced and analyzed separately. Ordinarily, the sample sent to the laboratory will weigh from 3 to 5 lb. and will be pulverized to about ¼ in. size. The original gross sample, which may amount to from 500 to 1000 lb., must be pulverized, mixed and quartered in such a manner as to maintain the same relative proportions of coal and impurities until the final 3- to 5-lb. sample is obtained; furthermore, coal has a marked tendency to lose moisture in crushing. This must be avoided as much as possible. The final sample should be placed in a moisture-proof container for shipment to the laboratory. Wooden boxes or sacks should never be used for samples in which moisture is to be determined.

Accuracy of Mine Sampling

During the last nine years the U. S. Geological Survey and its successor, the Bureau of Mines, has analyzed a large number of mine samples of coal, taken in connection with the investigation of coal as it occurs in the mine. A table was included in the paper to show the results from a series of duplicate 3-lb. can samples that were taken by the standard method of the Bureau of Mines. On account of the high percentages of moisture, ash and sulphur and the irregular distribution of the impurities, Illinois coals are unusually difficult to sample, yet, in spite of the high moisture content, the greatest difference of moisture in duplicate samples was only 0.3 per cent., with an average difference of 0.1 per cent. The average variation in ash of the duplicate samples from seven sections in two Pennsylvania mines was 0.1 per cent.; the maximum variation being 0.2 per cent. In the Illinois series the maximum variation was 1.6 per cent., the next highest difference being 0.7 per cent.

Sampling in the Laboratory

In the method used by the Bureau of Mines, moisture loss is avoided by air-drying the 3-lb. sample before pulverizing. The amount of moisture expelled during the air-drying process is recorded and added to the final moisture obtained by drying the powdered sample at 221 deg. F. The air-dry sample is quickly pulverized to 10 mesh by passing through a roll crusher, reduced on a riffle sampler to about 1 lb. and ground to a 60 mesh in a moisture-tight ball mill, which consists of rotating porcelain jars containing well rounded flint pebbles. The final powdered sample is preserved in a rubber-stoppered bottle to prevent change in moisture content.

Usually the laboratory sampling error with respect to ash, by the method just described, is less than 0.3 per cent., and seldom greater than 0.5 per cent. Where careful work is done by the sampler, the 0.5 per cent. limit should not be exceeded.

Incorrect Methods of Preparing Coal Samples

The determination of total moisture by drying a portion of the coarse sample in a steam oven at about 221 deg. F. will give low results, the error increasing with the size of the lumps. The method of drying the coarse sample at temperatures above 212 deg. F. and then pulverizing to a powdered sample for analysis with the assumption that the powdered coal is dry coal, will give quite erroneous results. The powdered sample will never be dry, but will contain from 0.3 to 1 per cent. moisture, which it has either failed to give up while drying in the coarse condition, or has taken up from the atmosphere, while being pulverized. The heat values are directly affected by the errors in the sampling and in the moisture determinations.

Abrasion in Ball Mills

In using any apparatus for pulverizing samples, the amount of contamination from abrasion of the pulverizing surfaces should always be investigated. The addition to the ash content may be found by determining the loss in weight of the grinding surfaces. The results of a number of tests on a ball mill showed only 0.004 per cent. increase in ash due to the abrasion from the pebbles. The extent of abrasion from the porcelain jars was shown in a series of tests to be 0.04 per cent. at the highest, which is less than the analytical error in the determination of ash.

Conclusion

To state definite limits of accuracy for coal analyses is almost impossible. The factors which influence the results are many and variable. They depend on the kind

and quality of coal, the method of sampling and analysis and the skill and experience of the analyst in the special field of coal testing.

With the exception of the volatile matter, fixed carbon and oxygen determinations, the best analytical methods are more accurate than the methods of sampling. The method of taking the original sample is often limited by the commercial conditions. The determination of the heat value with the use of properly standardized calorimeters and thermometers is reliable and comparable. Appreciable errors, when such occur, are due to sampling or a change in the composition of the sample by oxidation or loss of moisture. Finally, a statement of how the sample was taken should always go with the report of analysis. This will enable one who has a knowledge of coal to properly interpret the report.

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Avery Automatic Liquid Scales

This weigher is built with an even-arm balance, a beam supporting a weight-hopper at one end and a weight box at the other. It is designed to weigh liquids in unit amounts and record the summation of weights upon a counter, automatically, continuously and accurately, regardless of temperature and inlet pressure.

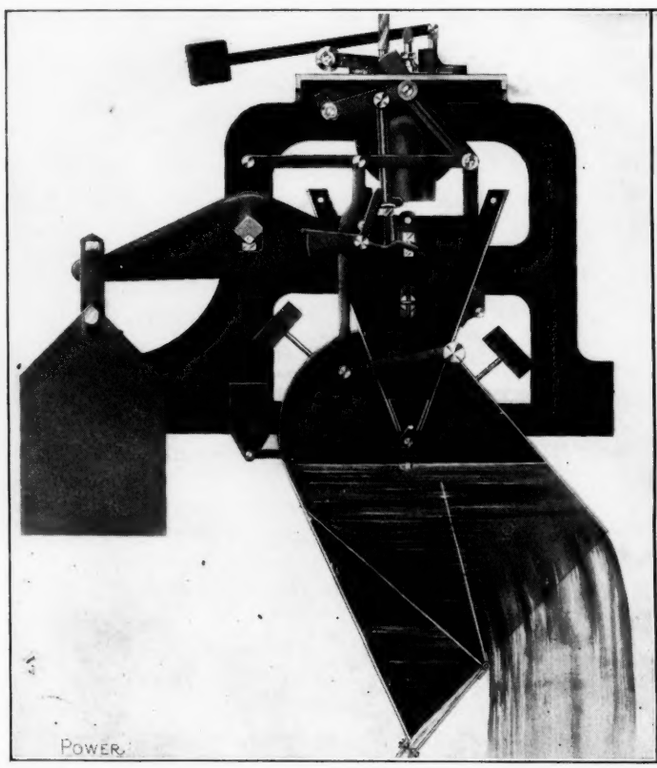

FIG. 1. DUMPING POSITION

Liquid enters at the top of the machine through a balanced valve, controlled by levers, into the weigh-hopper in a full stream, but the liquid is brought to a dribble, by reason of the combined weight of levers resting on a projection of the weigh beam, and thus partly closing the inlet valve. The weight of the levers is then transferred to a knife edge and a roller until an exact balance is reached. In traveling to a balance a projection releases a catch holding the hopper in position, and the hopper turns completely over, Fig. 1, because it is supported below the center of gravity. At the same time the inlet valve is closed and the toggle joints connected to the vertical lever are held rigidly in place. When the hopper is brought back to position by the counterweight the toggles are broken. This action opens the balanced valve and a new weighing is begun.

The chamber at the right of the bucket, Fig. 2, insures the release of all liquid. Becoming full, the liquid releases under the hinged plate slower than from the main hopper so that its weight holds the hopper down until all liquid has left. If any remains in this portion, it will drain out through a hole. A compensating lever and weight allow for the liquid in suspension at the time of cutting off the flow, this giving further accuracy.

This liquid weigher has many fields of usefulness. For power plants it automatically weighs and records all feed water passing to the boilers. For oil-burning furnaces, it weighs the amount of fuel oil consumed. The weigher is made by the Avery Scale Co., 726 Monadock Building, Chicago, Ill.

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A reduction in electric-power rates has been made by the Ontario Hydro-electric Commission to the municipalities which purchase energy through this commission (which supplies them over its own transmission lines from a Niagara

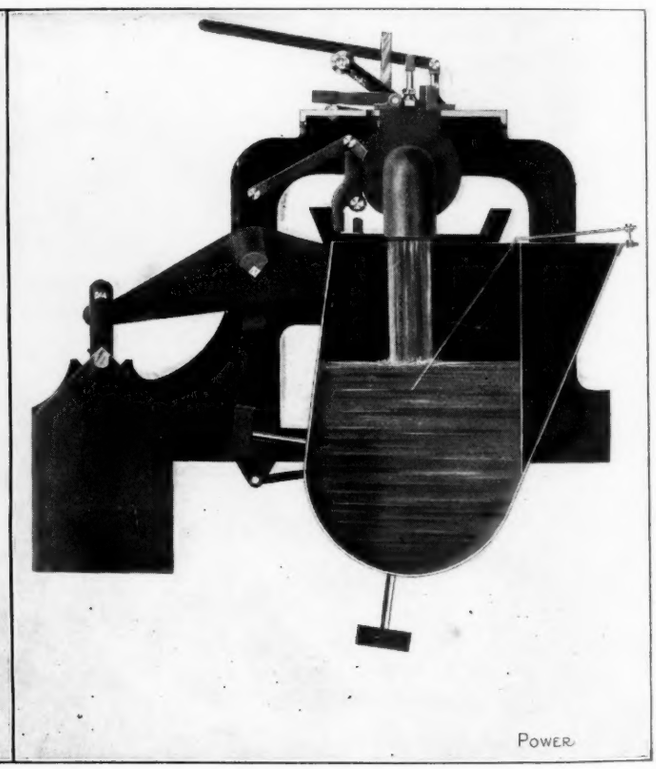

FIG. 2. FILLING POSITION

Falls plant). The new rates mean a decrease of some $100,000 gross income over the present figures. The total connected load of the system is now about 34,000 hp. It is claimed that the new rates are more than sufficient to cover the various charges together with proper sinking-fund installments. There was a yearly surplus of $62,000 at the end of Oct. 31, which sum is only $10,000 less than the whole sinking-fund charges for the first year. It was not planned to burden the pioneer purchasers of energy with sinking-fund and depreciation charges until the year 1914; but before reducing the rates as above noted, deductions for that purpose were made.

NEW PUBLICATIONS

THE METRIC SYSTEM IN A NUTSHELL. By Henry G. Bayer. Thirty-one 4x6½-in. pages; 20 tables of equivalents. Price, 35c. Henry G. Bayer, 232 Greenwich St., New York, N. Y.

This booklet contains 20 tables of equivalents of English and metric units, taken from the larger book by the same author, and reviewed before. It is arranged in a convenient form for the manufacturer and business man who wishes a general idea of the metric system and needs at hand tables to convert easily and quickly the quantities and measurements with which he deals.

THE MODERN GASOLINE AUTOMOBILE: ITS CONSTRUCTION, OPERATION, MAINTENANCE AND REPAIR. By Victor Page. Published by The Norman W. Henley Publishing Co., New York, 1912. Size, 5½x8¾ in.; 693 pages, illustrated. Cloth. Price, $2.50.

A very complete treatise on the modern gasoline automobile, written in a simple, nontechnical, yet convincing style. The general features of design, common to all cars, are first taken, up and then the special features are discussed, such as T-head, L-head and sliding-sleeve motors; planetary, progressive and selective transmission; the multiple-disk, cone, band and dry-plate clutch, etc. In this discussion the relative merits of each are pointed out.

Considerable space is also devoted to automobile accessories, such as lighting, windshields, etc., and particularly useful is the advice on the proper maintenance and operation of a car.

It is a book which every car owner who desires to be well informed on automobile practice should read.

ESSENTIALS OF ELECTRICITY—DIRECT CURRENTS. By W. H. Timble. Wiley Technical Series. Published by John Wiley & Sons, New York. Size, 5x7 in.; 271 pages, illustrated; cloth. Price, $1.25.

The aim of this little book is to give the practical man a working knowledge of the underlying principles of direct-current practice; hence all mathematical analyses are avoided and the subject is approached from the physical rather than the abstract viewpoint; in this connection, recourse is made to the water analogy.

The author, who has taught applied electricity in trade schools for several years, has recognized the needs of the practical man in this line and has chosen the extensive use of problems to drive home the text matter. Several examples are worked out after each important topic or statement, and a large number of problems are appended at the end of each chapter. In connection with the latter problems it might have been an aid to the man who is using the book for self-instruction if a list of answers had been given at the back.

All important conclusions and laws are in heavy type, and a summary is given at the end of each chapter. The divisions of the subject covered are: Ohm's law, simple electric circuits, combinations of series and parallel systems, electric power, wire and wiring systems, generators and motors, batteries and wiring diagrams. Considerable space is also devoted to locating and correcting trouble in generators and motors, a most useful subject for operating men. Moreover, the illustrations are well chosen.

In point of criticism may be mentioned several loose statements in the text: On page 15 the author says: "An ammeter is inserted into the circuit, and becomes a part of the circuit and receives the full current of the circuit"; the subsequent illustrations and problems bear this out.

While this would apply to circuits handling very small currents, where large currents are to be handled, such as on a switchboard, ammeter shunts would have to be employed. The author, however, makes no mention of shunts.

Again, on page 129, is the statement, "Self-excited machines sometimes change their polarity when not in use." While this is true, it would leave the reader to infer that they never change their polarity when in use—a condition which frequently happens.

On page 108 the author states that the neutral wire is usually the same size as each of the other two. As a matter of fact, it is usually half the size of each of the outside wires, and sometimes less.

The following statement is also made:

If electric power is generated outside the machine and is brought to it, and if this power puts the machine in motion and thus runs other machinery, the machine is called a motor. If the machine derives its mechanical power from some source outside itself, and delivers electric power, it is called a generator. The term dynamo includes both generator and motor.

While any direct-current generator may be run as a motor, it seems a misnomer to apply the term "dynamo" to a motor. Common usage has made the dynamo synonymous with generator, and even the dictionaries (both electrical and general) define a dynamo as a machine for converting mechanical into electrical energy by magneto-electric induction.

On the whole, the merits of the book greatly outweigh its defects, and it should prove very useful to the man who must acquire a working knowledge of the subject in a short time.

Midwinter A. I. E. E. Convention

The midwinter convention of the American Institute of Electrical Engineers, held Feb. 26 to 28, was devoted exclusively to a discussion of data bearing upon a revision of the present Standardization Rules, which have been found inadequate to cope with present requirements in the electrical field.

In all, 45 papers were presented—the large number making it necessary to read most of them in abstract or by title only. The papers were classified under four groups, the first dealing with heating, heat measurements and rating by heat; the second with methods in determining losses in apparatus; the third with methods of testing apparatus for performance; and the fourth with miscellaneous subjects relating to rating.

The discussions, both written and oral, were numerous, and for the most part very largely of a constructive nature.

The Standards Committee, under whose direction the convention was held, deserves credit for the businesslike manner in which the meeting was conducted and the large number of papers disposed of.

The convention was concluded with a reception and dance at the Hotel Astor, on the evening of Feb. 28.

National Tube Co.'s Book of Standards

To the engineer who needs practical, accurate information concerning pipes, tubes, joints, valves, fittings, etc., and who desires a strictly pipe handbook, the 1913 revised edition of the National Tube Co.'s "Book of Standards" will be of immense value. It is not a catalog nor padded with advertising matter. This edition is larger and more complete that the older one, contains 559 pages, is printed on Canterbury Bible paper and will fit the pocket readily. The index has about 4000 references, and all the headings are cross-indexed.

A descriptive article covers the main process of manufacturing both welded and seamless tubes and gives much information on the threading, durability, physical properties, etc., of both National pipe and Shelby seamless steel tubes. Weights, dimensions, threads per inch, test pressures, sections of joints, specifications, etc., of the various kinds of pipes and tubings made are also given as well as a valuable article on protective coating, Matheson joint pipe and Converse joint pipe.

Several pages contain tables of lap-weld and seamless tubes, upset and expanded, wrought pipe bends, butted and strapped joints, pump joints, valves and fittings, including various kinds of nipples and flanges, hand railings and ladders, working barrels, cylinders, Shelby seamless specialties, Shelby seamless cold-drawn trolley poles, tables of physical properties of Shelby seamless steel tubes and of carbonic acid gas, Briggs' standard folding power of boiler tubes and thermal expansion of iron and steel tubes.

The articles on the strength of tubes and cylinders under internal fluid pressure and collapsing pressures are from papers by Prof. R. T. Stewart, of the University of Pittsburgh. Several of the formulas are compared, and results of actual tests are given. These are also tables which show the probable collapsing and bursting strengths of standard tubes. These articles and tables will prove of immense benefit in connection with boiler engineering problems.

An article on safety factors and safe working stresses shows through what ranges values should be used for safe operation. Information is also given on water, gas, steam and air insofar as they concern tubular products.

The many tables include fifth roots and fifth power; decimals of a foot for each 1/64 in.; decimals of an inch for each 1/64; wire and sheet metal gages in approximate decimals of an inch. Other features are proportions of screw threads, nuts and bolt heads, area and weight factors for tubes and pipes; special tests by which to find directly the weights of nearly all sizes and thicknesses of steel tubing up to 36 in.; tables showing properties of tubes and round bars, with an explanatory article, and giving various physical properties, including circumference, area, weight, surface in square feet, values, moment of inertia, radius of gyration, etc., for tubes and round bars up to and including 36 in.

The metric system is included with conversion methods for most of the more commonly used measures, including temperature, and a glossary of terms used in the pipe and fittings trade. The meanings of the less well known words in the trade are defined.

The book is published by the National Tube Co., Pittsburgh, Penn., and will be sent on receipt of $2.

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To Cooperate for Public Betterments

Arthur Williams, of the New York Edison Co., and chairman of the public policy committee of the National Electric Light Association, was the host, on Tuesday evening, Feb. 18, of a dinner in the Union League Club, New York City, to a number of representatives of electric lighting and street railway companies from all over the country. The dinner was followed by an informal discussion on ways and means of coöperating with the public in the management of public utilities.

Gen. George H. Harries, president of the Louisville Lighting Co., referred to what he called a partnership with the companies and the public and said that only in this way could the best coöperation be obtained.

After some discussion of minimum wages and old age pensions, Mr. Williams said that he did not like the term "old-age pensions," but preferred "service annuities." What the old employees received was the result of rendering service as well as performing work.

Some of those there were Frank Hedley, vice-president and general manager of the Interborough Rapid Transit Co.; Thomas N. McCarter, president of the Public Service Corporation of New Jersey and chairman of the committee on public relations of the American Electric Railway Association; Patrick Calhoun, president of the United Railroads of San Francisco; Oscar T. Crosby, president of the Trenton & Mercer County Traction Co.; James H. McGraw, president of the McGraw Publishing Co.; William H. Heulings, Jr., assistant secretary of the J. G. Brill Car Co.; C. Loomis Allen, president of the Newport News & Old Point Comfort Ry. & Electric Co.; C. C. Pierce, vice-president of the Providence & Fall River Street Ry. Co.; J. H. Pardee, president of the J. G. White Management Corporation and H. C. Donecker, secretary and treasurer of the American Electric Railway Association.

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Gas Engine Cylinder Head Blows Out

When starting a gas engine in the factory of the S. L. Pierce Shoe Co., Cleveland, Ohio, at 7:30 a.m., on Feb. 19, the cylinder head was blown out. The engine was about 12 years old. Paul Cooley, the engineer, was thrown about 15 ft., and injured on the head and back. The fireman was not seriously injured. The engine is said to operate on natural gas, and the explosion was due to backfiring. The owners of the engine refused to supply any other information.

SOCIETY NOTES

At the special meeting of the American Museum of Safety on Friday evening, Feb. 21, at Delmonico's, New York City, the Harriman medals were discussed. The gold medal will be awarded by the Museum of Safety to the railroad in the United States which will have made the greatest progress in safety and accident prevention, first in safeguarding the traveling public, and second, in preventing accidents among employees. The silver medal will be awarded to an operative head, such as a division superintendent who has himself accomplished notable work along safety and accident prevention lines. The bronze medal will be awarded to a switchman, a brakeman or a yardman who has performed some kind of service or in some way contributed to the safety of the public or his fellow workmen. The medals will be awarded annually in January, the first presentation being in 1914. The committee appointed by President Arthur Williams to take charge of all matters relative to the medal consists of President Hadley, of Yale; the U. S. Commissioner of Labor; Secretary W. F. Allen, of the American Railway Association; Samuel O. Dunn, eidtor of the "Railway Age Gazette," and Franklin K. Lane, chairman of the Interstate Commerce Commission. The Harriman medal is the fifth which the Museum now awards annually. Among the honorary guests at the dinner and meeting were H. L. Doherty, James Speyer, Dr. F. L. Hoffman, Dr. William H. Tolman, Dr. Norman E. Ditman, A. A. Hopkins, Dr. Charles A. Doremus, T. Commerford Martin and A. A. Anderson.

OBITUARY

WILLIAM HENRY WHITE

On Feb. 27, Sir William Henry White the originator of the modern battleship, died suddenly in London after a stroke of apoplexy.

He was born in Devonport in 1845. He was in the constructive department of the Admiralty from 1867 to 1883, and rose to the rank of chief constructor; he was professor of naval architecture at the Royal School of Naval Architecture and the Royal Naval College from 1870 to 1881; he organized and directed the warship building department of Armstrong & Co., at Newcastle, from 1883 to 1885; he was director of naval construction and assistant controller of the royal navy from 1885 to 1902, and during that time designed many of Great Britain's big fighting ships.

Because of ill health Sir William resigned his office and was awarded a special grant of money by vote of Parliament in recognition of his services to the navy. He was a consulting designer of the "Mauretania" for the Cunard Steamship Co.

On his retirement from the public service Sir William White took a leading part in the proceedings of the principal British engineering societies, and was particularly interested in the promotion and organization of technical education. He was president of the Institution of Civil Engineers, the Mechanical Engineers, the Marine Engineers, the Institute of Metals, and the Junior Institution of Engineers.

Many engineering societies in Great Britain and abroad have enrolled him as honorary member. Among these are the American societies of Civil Engineers, Mechanical Engineers and Naval Architects, the Canadian Society of Civil Engineers, and the Association Technique Maritime of France. The John Fritz Medal for 1911 was awarded to Sir William White "for achievements in naval architecture" by the special board appointed by the four great American engineering societies. At home, he was an honorary member of many engineering societies, including the Society of Engineers, the Engineers and Shipbuilders in Scotland, the North East Coast Institution of Engineers and Shipbuilders, the Liverpool Engineering Society and the Aberdeen Association of Civil Engineers; a fellow of the Royal Society, the highest scientific distinction possible to a British citizen; a fellow of the Royal Society of Edinburgh and a member of the Royal Academy of Sciences in Sweden. Honorary degrees were conferred upon him, including the doctorate of science of Cambridge and Durham in England, and of Columbia University in the City of New York; the doctorate of laws in Glasgow; the doctorate of engineering in Sheffield University. As the result of his persistent advocacy, professorships of naval architecture have been founded in the universities of Liverpool and Durham.

PERSONALS

Ernest B. Lloyd, M. E., has accepted the position of chief engineer of the Chicago State Hospital, at Deeming, Ill. Mr. Lloyd was until recently with the Kankakee State Hospital.

John J. McDonald, a salesman for the William B. McVicker Co., New York City, for the past three years, has accepted a position with J. L. Quimby & Co., of that city, in a similar capacity.

John Fritz, the eminent engineer and iron master, gave his residuary estate, amounting to about $150,000, to Lehigh primarily as an endowment fund for the maintenance of the Fritz Engineering and Testing Laboratory. Mr. Fritz, who was a trustee of Lehigh from its founding in 1866, gave the laboratory to the university in 1910. It is one of the best equipped of its kind in the world, and its construction and equipment were personally supervised by Mr. Fritz.

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J. G. White & Co., Inc., believing that the separate incorporation and independent management of its three major departments will increase the general efficiency of its work, has formed, as subsidiary companies, the J. G. White Engineering Corporation and the J. G. White Management Corporation. The new companies have acquired the good will, contracts, equipment and other assets of the engineering, construction and management departments of the present company. J. G. White & Co., Inc., will continue as an active financing and owning company in the general field of engineering and public utility enterprise.